



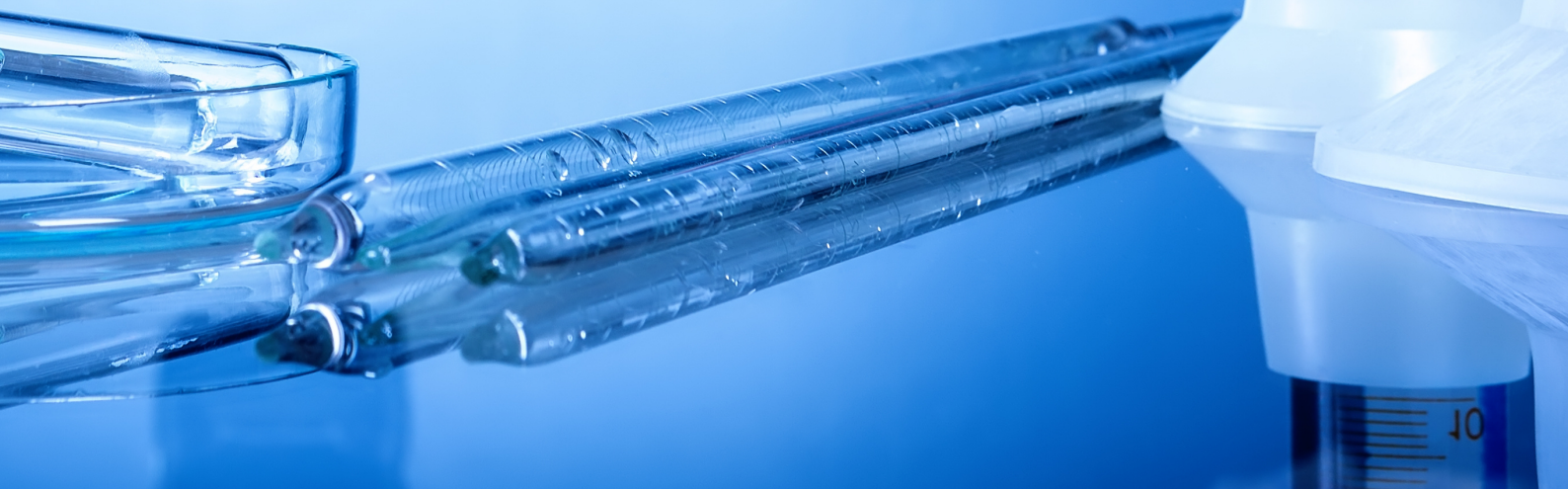
## 25<sup>TH</sup> ANNIVERSARY CONGRESS

OCTOBER 28-30, 2020

# BOOK OF ABSTRACTS

Editors:

Dela, F., Müller, E., Tsolakidis, E.



**25<sup>th</sup> Annual Congress of the**  
**EUROPEAN COLLEGE OF SPORT SCIENCE**  
**28<sup>th</sup> - 30<sup>th</sup> October 2020**  
**BOOK OF ABSTRACTS**

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Dela, F., Müller E., Tsolakidis, E.

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# Welcome

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Dear Valued Member of our Sport Science Community,

Welcome to the 25th ECSS Anniversary Congress, 2020!

The COVID-19 virus is causing much human suffering and economic hardship on a global scale. The ECSS Executive and Scientific Boards have done all that is possible to assess the full picture of how the virus has impacted, and can impact the College moving forward amidst the current chaos, uncertainty and instability.

After careful consideration, and very detailed discussions, we have decided to cancel the ECSS Sevilla 2020 Congress and to organise the 25th ECSS Anniversary Congress, 28-30 October 2020, which will be a virtual congress.

The scientific programme offers a broad interdisciplinary spectrum of current research in sport science. The highlights of this congress will be the live streams of three plenary sessions, more than 25 invited sessions, and the Young Investigators Award (YIA) presentations. In addition you will be able to access and view a huge amount of video streamed oral, traditional poster and e-poster presentations.

The entire 25th ECSS Anniversary Congress programme will be made available for you, via your personal ECSS account, until the end of December 2020.

This virtual congress will be a new experience for all of us. We are confident that with resilience and a spirit stronger than ever before, it will be a fantastic experience for all involved. We hope that you enjoy the 25th ECSS Anniversary Congress and we are already looking forward to welcoming you in person at the new ECSS Sevilla Congress in 2021!

Yours in sport science,

Erich Müller, *ECSS President*

Flemming Dela, *Chair ECSS Scientific Board*

Elias Tsolakidis, *ECSS Technical Director*



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# Live Sessions: Wednesday, October 28, 2020

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09:00 - 11:00

## IS-PN03 MUSCLE FUNCTION AND RESISTANCE TRAINING ADAPTATIONS IN FEMALES THROUGHOUT THE LIFE SPAN

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### INFLUENCE OF MENSTRUAL CYCLE ON MUSCLE FUNCTION AND INJURY RISK

HANSEN, M.

AARHUS UNIVERSITY

#### INTRODUCTION

Most reproductive aged females are exposed to fluctuations in various endogenous hormones throughout the menstrual cycle. Early in the follicular phase of the menstrual cycle (the bleeding phase) both oestrogen and progesterone are low, oestrogen then rises during the late follicular phase and after ovulation both oestrogen and progesterone are elevated. These hormones, specifically oestrogen, have been suggested to influence muscle strength, but also injury risk.

#### METHODS:

This presentation will provide an overview of the current knowledge on variation in muscle function and injury risk over the menstrual cycle.

#### RESULTS:

Many women experience mental or physical negative symptoms in the last days of the cycle and the beginning of the cycle. In line with this, there is data indicating that performance is impaired in the early follicular phase. Still, there is no clear picture in regard to the influence of the hormonal fluctuations on muscle function and performance yet. This may relate to differences in design and methodological issues between the studies, but also the fact that the individual female athletes are differentially affected.

Knee joint laxity and the risk of sustaining a knee injury seems to be enhanced in the late follicular phase around ovulation where the estrogen level is peaking. This highlights the need for preventive exercises to lower the high risk of sustaining a knee injury in female compared to male athletes.

#### CONCLUSION:

There is a growing interest in clarifying the importance of hormonal fluctuations on female athletes performance and injury risk. However, previous research does not show a clear picture, which may be explained by methodological differences and limitations.

### EFFECTS OF ORAL CONTRACEPTIVES ON MUSCLE FUNCTION AND RESISTANCE TRAINING ADAPTATIONS

JANSE-DE-JONGE, X., THOMPSON, B., SCULLEY, D.

THE UNIVERSITY OF NEWCASTLE, AUSTRALIA

#### INTRODUCTION

Oral contraceptives (OC) are often used in the general community and amongst female athletes. The most common OC is the combined monophasic OC, which keeps the concentration of both ethinyl estradiol and progestin constant throughout the 21 days of active pills. It is important to consider the different types of progestin in OC, which may have low or high levels of androgenicity. Androgenicity refers to the ability of the progestin to produce masculine characteristics. Oestrogen has been shown to have a positive effect on muscle function, so the administration of exogenous female hormones through OC use may also have effects.

This presentation will provide an overview of the current knowledge on the potential effects of OC on muscle performance, as well as the emerging research on adaptations to resistance training in females. Furthermore our recent study on the effect of the monophasic combined OC cycle with high and low androgenicity on various aspects of muscle function, as well as acute responses to a resistance training session, will be presented.

#### METHODS

Eighteen moderately active females (10 taking a high androgenicity OC and 8 taking a low androgenicity OC) aged 18–30 years were tested three times throughout the OC cycle. Testing occurred on day 4–7 (non-active phase), day 10–13 (early hormone phase) and day 19–23 (late hormone phase). Counter movement jumps (CMJ), bilateral hop jumps, handgrip strength, isometric knee extensor strength and isokinetic knee flexion and extension torque at 60°/s and 240°/s were assessed immediately prior to and after a leg resistance training session.

#### RESULTS

Repeated measures ANOVA showed no significant changes over the OC cycle in both high and low androgenicity groups for any of the isometric and slow isokinetic strength measures. For the high androgenicity group, isokinetic knee flexion torque at 240°/s was significantly higher in the late hormone phase compared with the early hormone phase. For the low androgenicity OC group, time of flight for the CMJ was higher in the early hormone phase compared with the late hormone phase.

For the responses to the training session most measures showed no significant changes over the OC cycle. However, in the high androgenicity OC group, isokinetic knee flexion at 240°/s was significantly higher in the early hormone phase compared with the non-active pill phase and the late hormone phase.

#### CONCLUSION

The muscle function results suggest that the faster aspects may be influenced by exogenous female sex hormones in OC and that androgenicity seems to affect these results. For acute responses to a resistance training session, only the high androgenicity group showed a change over the OC cycle. Further OC research focussing on fast and explosive aspects of muscle function, as well as training adaptations and androgenicity is recommended.



## MUSCLE FUNCTION, RESISTANCE TRAINING ADAPTATIONS AND HORMONE REPLACEMENT THERAPY IN POST-MENOPAUSAL WOMEN

SIPILA, S.

UNIVERSITY OF JYVÄSKYLÄ

**INTRODUCTION:** Women experience drastic hormonal changes during mid-life due to menopausal transition. These changes are known to lead to bone loss and potentially also to loss of muscle mass and physical performance. Hormone therapy (HT) and physical activity (PA) may counteract menopause-related decline. We investigated the associations between menopausal status and muscle mass and functional performance and roles of HT and PA on these factors in middle-aged women.

**METHODS:** In total, 1393 47-55-yr-old women were assigned to pre-, early peri-, late peri- and postmenopausal groups. Perimenopausal groups were followed up until postmenopausal. Fifteen 54-62-yr-old MZ twin pairs discordant for HT were recruited. In addition, 80 women aged 50-57 were randomly assigned to exercise (Ex), HT, exercise+HT (ExHRT) and control (Co). The exercise groups participated in a high-impact resistance training. HT or placebo was carried out double-blind. Appendicular lean mass (ALM) was measured with DXA and thigh muscle cross-sectional area (CSA) with CT. Physical performance was measured with grip and knee extension (KE) force, vertical jumping height, maximal walking speed and 6min walking distance. PA was self-reported.

**RESULTS:** ALM declined across menopausal groups ( $p<.001$ ). Premenopausal women had greater ALM than postmenopausal women ( $p<.001$ ). Higher level of PA was associated with greater ALM in pre- ( $\beta=.171$ ;  $p=.002$ ), late peri- ( $\beta=.289$ ;  $p<.001$ ) and postmenopausal ( $\beta=.278$ ;  $p<.001$ ) women. Postmenopausal women had 12N lower grip force ( $p<.001$ ) and 1.1 cm lower jumping height ( $p<.001$ ) than premenopausal women. Peri- and postmenopausal women with high PA performed better in KE, 6min walking test, and jumping height than those with low PA. When perimenopausal women were followed up until postmenopausal, ALM declined by -1.2% ( $p<.001$ ), muscle CSA by -0.8% ( $p=.021$ ), grip force by -2% ( $p<.001$ ), KE by -3% ( $p<.001$ ) and jumping height by -2.6% ( $p<.001$ ). A 2% ( $p<.001$ ) increase in 6min walking distance was observed. A significant interaction of PA by time was observed in grip force ( $p<.001$ ) and jumping height ( $p=.003$ ), indicating a greater decline in the high PA group. HT users had faster walking speed (7%,  $p=.019$ ), greater muscle power (16%,  $p=.023$ ) and larger relative muscle CSA (8%,  $p=.047$ ) than in their co-twins. When HT was incorporated into a 1-yr resistance training program, significant increase in knee extension torque (8.3%) and jumping height (17.2%) when compared with Co (-7.2%,  $p<.001$ ) was observed. Jumping height increased also after HT alone (6.8%,  $p=.014$ ). Muscle CSA increased significantly in the HT (6.3%) and ExHT (7.1%) groups when compared with the Co (0.7%,  $p<.001$  for both comparisons).

**CONCLUSION:** Menopause status is associated with decline in muscle mass and physical performance. The beneficial effects of HT combined with physical training may exceed those of HT or exercise alone.

## OP-BM11 AGEING AND BALANCE AND FALLS

### MODULAR CONTROL OF MOTOR OUTPUT AS A LIMITING FACTOR FOR FALL-RESISTING SKILL LEARNING

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**INTRODUCTION:**

The human neuromotor system is constantly challenged by the natural environment to adopt robust motor control strategies for coping with perturbations and avoid falling (1). Since falls may result from a variety of postural threats, the ability to generalise previously learned responses to new challenges might be beneficial. Although rapid adaptability in the human balance control system to 'perturbation training' has been frequently reported, adaptations to stability control do not seem to necessarily transfer to an untrained motor task (2). In this study, we examined the modular organisation of the motor system in balance recovery responses during three different perturbation tasks to detect specific neuromotor factors facilitating or limiting generalizability of learning.

**METHODS:**

Forty young and middle-aged adults (range 20-52 yrs) were recruited either to an intervention group (eight separate sudden trip-like perturbations during treadmill walking at 1.4 m/s;  $N=29$ ) or a control group (unperturbed walking;  $N=11$ ). After treadmill walking, all participants were exposed to a sudden loss of balance from a forward-inclined position (lean-and-release; LRT) and an overground trip. A motion capture system (120 Hz; Qualisys, Gothenburg, Sweden) was used to obtain movement kinematics. The anteroposterior margin of stability (MoS) was determined as the difference between the anterior boundary of the base of support and the extrapolated centre of mass at foot touchdown (TD). In addition, muscle activity of 13 ipsilateral leg muscles was recorded for all three balance tasks using EMG (1080Hz; Delsys, USA) and muscle synergies were extracted using non-negative matrix factorisation (1).

**RESULTS:**

After treadmill trip-perturbation training, the intervention group demonstrated an improved recovery response (increased MoS at TD of the first recovery step;  $P<0.05$ ). Nevertheless, no superior recovery response was found during the LRT compared to age-matched controls. Recovery performance from overground tripping was in contrast enhanced for the intervention group as indicated by greater MoS at TD of the first recovery step ( $P<0.05$ ). The number of muscle synergies was five in both treadmill walking and LRT. However, the temporal and spatial components revealed profound differences in the timing and function of the muscles recruited to cope with the two types of perturbations.

**CONCLUSION:**

The findings reveal that adaptations to stability control from single session perturbation training are highly task-specific, with transfer of learning taking place only between different conditions of the same task, but not different tasks. The motor system uses different modular strategies to organise the recovery responses to tripping and sudden loss of balance. This suggests that the synergistic control of motor output is potentially regulating the generalisability of fall-resisting skills.

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**AGEING DOES NOT CHANGE THE CONTRIBUTION OF MUSCLE PROPRIOCEPTION IN THE SENSE OF FORCE**

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UNIVERSITÉ LIBRE DE BRUXELLES

**INTRODUCTION:**

Ageing is accompanied by a decline in gross and fine motor skills that likely reflects alterations in the force control mechanisms (1). The proprioceptive system is an essential component of force control that undergoes structural and functional changes with ageing (2). This may lead to a decreased contribution of muscle proprioception in force control, as reported for postural control during upright standing (3). Therefore, the aim of this study was to seek if the contribution of proprioception in force control decreases with ageing. To this end, we assessed young and older adults on the sense of force (SF), which is part of conscious proprioception (4), with or without simultaneous mechanical tendon vibrations aimed at perturbing muscle proprioception, and thereby SF. We hypothesized that a lesser contribution of muscle proprioception in SF should reduce the perturbations due to the vibration.

**METHODS:**

Twenty young ( $28 \pm 6$  yr) and 21 older ( $74 \pm 7$  yr) healthy adults performed a SF test with the wrist flexors of the dominant arm. First, subjects learned to produce two levels of force [5 and 20% of the force developed during a maximal voluntary contraction (MVC)] with a visual feedback of the force signal. Then, subjects had to reproduce the same levels of force for 15s without visual feedback. Subjects performed 3 trials for each force level. Then, we used the same procedure with vibrations (80 Hz, 1-mm amplitude) applied over the wrist during trials without visual feedback. The SF score corresponded to the difference between the force produced without visual feedback and the target force in trials with (SF-VIB) and without (SF-CON) vibrations; a greater SF score indicates a worse SF.

**RESULTS:**

The SF-CON was similar between young and older adults at 5% (young:  $2.7 \pm 2.0$  N; older:  $3.0 \pm 4.2$  N,  $p=0.79$ ) and 20% MVC (young:  $0.9 \pm 4.6$  N; older:  $0.8 \pm 7.3$  N,  $p=0.97$ ). The SF-VIB was greater than SF-CON ( $p<0.001$ ) at 5% MVC, regardless of age (young:  $4.9 \pm 2.9$  N; older:  $7.0 \pm 5.9$  N,  $p=0.16$ ). However, at 20% MVC, the SF-VIB ( $-0.4 \pm 5.8$  N) did not differ from SF-CON in young adults ( $p=0.44$ ) whereas it was greater in older adults ( $6.4 \pm 10.7$  N,  $p=0.05$ ).

**CONCLUSION:**

Our results indicate that healthy ageing does not alter the SF for wrist flexors. The absence of a lesser vibration effect on SF in older adults rejects our hypothesis of a decreased contribution of muscle proprioception in the SF with ageing. However, the greater SF-VIB for 20% MVC in older adults may indicate an age-related deficit in sensori-motor integration in response to proprioceptive perturbations (5).

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**ESTIMATED VS. FORCE PLATE-DERIVED SIT-TO-STAND POWER IN OLDER PEOPLE.**

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**INTRODUCTION:**

Mechanical power has been demonstrated to be an essential concept in geriatrics due to its strong relation with functional outcomes (1). In this sense, the 5-rep sit-to-stand (5-STs) power test has emerged as a valid, easy and inexpensive method to assess mechanical power in older people (2). However, this test has not been validated yet against power values measured during the STS task. The aims of this study were (i) to assess the validity the STS power test; and (ii) to assess its relationship with physical performance in older individuals.

**METHODS:**

Thirty-four older adults (17 women;  $71.5 \pm 4.3$  years old; BMI:  $28.9 \pm 4.9$  kg·m<sup>-2</sup>) participated in this study. Habitual (HGS) and maximal gait speed (MGS) and timed up and go (TUG) test were measured. The participants performed the 5-STs test over a force platform (Kistler, Switzerland). Mean concentric power during each STS repetition was calculated as the product of measured force and velocity (distance was calculated as the difference between leg length and chair height, and time was obtained from force plate-derived data). In addition, STS power was estimated using the previously validated equation (2). Paired t-tests and Pearson's correlations were used in SPSS (SPSS Inc., EEUU).

**RESULTS:**

No significant differences were found between estimated and measured velocity ( $0.49 \pm 0.13$  vs  $0.51 \pm 0.12$  m·s<sup>-1</sup>) and power ( $340.1 \pm 122.4$  vs  $329.0 \pm 111.7$  W) values (both  $p>0.05$ ). In contrast, force differed significantly between estimated and measured values ( $684.5 \pm 143.5$  vs  $641.9 \pm 136.7$  N;  $p<0.05$ ). In addition, significant large correlations were observed between estimated and measured values in terms of velocity ( $r = 0.91$ ), force ( $r = 0.95$ ) and power ( $r = 0.93$ ) (all  $p<0.05$ ). On the other hand, both estimated and measured mechanical power were associated to habitual gait speed ( $r = 0.47$  vs  $0.35$ , respectively), maximal gait speed ( $r = 0.63$  vs  $0.53$ , respectively) and TUG time ( $r = -0.59$  vs  $-0.49$ , respectively) (all  $p<0.05$ ).

**CONCLUSION:**

No differences were found between estimated and force plate-derived STS power values in older people. In addition, estimated and measured STS power data were largely correlated. Finally, although both estimated and measured STS power were associated with physical performance,  $r$  values were found to be superior for estimated STS power.

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**CORTICOSPINAL CONTROL OF HUMAN LOCOMOTION: A NEW DETERMINANT OF AGE-RELATED SARCOPENIA?**

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**INTRODUCTION:**

Sarcopenia is an age-related muscle disorder officially recognized by the World Health Organization with a specific ICD-10 code (Falcon et al., 2017). Many operational definitions are present for the diagnosis of sarcopenia, although an international consensus is lacking. The need of improving the current state of the art for sarcopenia screening as well as unveiling possible underlying novel mechanisms have been recently suggested by the Centers for Disease Control and Prevention (Falcon et al., 2017). Mounting evidence hints towards changes in corticospinal communication, where corticomuscular coherence (CMC) can reflect an effective mechanism of corticospinal interaction. Gait is a locomotor task driven by neural inputs directed to skeletal muscles (van Asseldonk et al., 2019) and CMC can be assessed during locomotion in an ecologically valid scenario by means of concurrent Electroencephalography (EEG) and Electromyography (EMG) (Gennaro et al., 2018).

**METHODS:**

The aim of this study was to perform the screening of sarcopenia in community-dwelling older adults (n=198) and explore the possibility of using CMC measured during overground walking by means of EEG-EMG assessments to discriminate between sarcopenic (n=11) and non-sarcopenic individuals (n=11).

**RESULTS:**

Receiver Operating Characteristic (ROC) showed high sensitivity, precision and accuracy of CMC assessed from the EEG sensor located over the vertex (Cz) and EMG sensors placed over Vastus Medialis muscle [Cz-VM; AUC (95.0%CI): 0.98 (0.92 – 1.04), sensitivity: 1.00, 1-specificity: 0.89,  $P < 0.001$ ] and over Biceps Femoris muscle [Cz-BF; AUC (95.0%CI): 0.86 (0.68 – 1.03), sensitivity: 1.00, 1-specificity: 0.70,  $P < 0.001$ ]. Data Analysis with Bootstrapped Estimation of these muscles showed significant differences with large magnitude of effect between sarcopenic and non-sarcopenic individuals [Hedges  $g$  (95.0%CI): 2.2 (1.3 – 3.1),  $p = 0.005$  and Hedges  $g$  (95.0%CI): 1.5 (0.7 – 2.2),  $p = 0.010$ ; respectively].

**CONCLUSION:**

This exploratory investigation shed a light on the role of corticospinal control of locomotion as possible new determinant underlie sarcopenia as well as a novel strategy to accurately distinguish between sarcopenic and not sarcopenic individuals. Moreover, CMC assessed during walking in an ecologically valid scenario might represent a potential strategy in clinical settings for future treatments aiming to counteract sarcopenia as well as to monitor the progression or the potential recovery following other treatment interventions targeting this age-related muscle disorder. To the best of our knowledge this is observed and reported for the first time.

**Invited symposia****IS-AP10 MAXIMAL FAT OXIDATION: NEW METHODOLOGY, INSIGHT AND PERFORMANCE RELATIONSHIPS****MAXIMAL CAPACITY FOR FAT OXIDATION DURING EXERCISE: HISTORICAL CONTEXT, NEW METHODS, AND ASSOCIATIONS WITH PERFORMANCE**

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The term Maximal Fat Oxidation (MFO) is commonly used to describe an individual's peak rate of fat oxidation as estimated by indirect calorimetry during an incremental exercise test. Paramount to the determination of MFO is the validity of indirect calorimetry across a wide range of exercise intensities, particularly when incremental exercise test stages are short in duration. When MFO has been assessed, it seems clear that considerable inter-individual variability exists; in cross-sectional studies of healthy individuals MFO can range from  $<0.2$  g/min to  $>1.0$  g/min. Aerobic capacity, self-reported physical activity level, biological sex and self-selected dietary carbohydrate and fat intake account for almost 48% of the observed inter-individual variability in MFO (Fletcher et al, Am J Clin Nutr 105(4):864-72, 2017). A high MFO reflective of a high capacity to utilize fat as fuel during exercise has in some instances been related to prolonged endurance exercise performance. Whether this is associative or causal remains to be determined, but developing a high capacity to utilize both fats and carbohydrates as energy substrates would seem most effective for endurance performance optimization. This presentation will address historical and contemporary developments around MFO and will be of broad interest - including for those working in exercise physiology, metabolism and nutrition – providing stimulating new information for scientists and practitioners alike.

**13C-BREATH RATIO AND LC-IRMS FOR MEASUREMENT OF FAT OXIDATION TO VO2MAX: A NEW METHOD FOR COMPETITION INTENSITIES**

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Historic studies using indirect calorimetry (IC) and the large body of literature utilising the Fatmax test have contributed to the current paradigm that fat oxidation reaches a maximum of no more than about 65%VO<sub>2</sub>max or the blood lactate threshold. However, limited intensity resolution and extended assumptions relating to HCO<sub>3</sub><sup>-</sup>/CO<sub>2</sub> pool stability places in question the fat oxidation rates using IC in nearly all published incremental tests. Meanwhile, elite athletes actively train long to raise skeletal-muscle oxidative capacity and fat oxidation to spare glycogen - an important mechanistic determinant of performance; and in vogue, is high-intensity exercise to promote fitness and fat metabolism. Therefore, a valid and reliable assay of fat oxidation within the competitive exercise intensity range ( $>80\%$ VO<sub>2</sub>max) is required.

To build such and assay, we used the breath 13C ratio (RATIO) approach, that is independent of VCO<sub>2</sub> and acid-base issues. The protocol comprised a glycogen depletion-repletion protocol using 13C-enriched dietary carbohydrate, incremental exercise, and determination of

substrate utilisation from fat (13C background) and 13C-enriched skeletal muscle glycogen determined by liquid chromatography isotope ratio mass spectrometry.

In the first two studies, 10 trained men completed a 60-min incremental step protocol to resolve Fatmax rate and intensity. 13C-enriched skeletal muscle glycogen content was manipulated by carbohydrate intake within the repletion period via high (2xHI, % energy: carbohydrate 69, fat 18, protein 13) and low (LO: 18, 62, 13) carbohydrate diets. 60-h later, participants were biopsied (V. lateralis) before completing an incremental ramp test (%peak power output/min: 50%/20, 62.5%/15, 72.5%/10, 77.5%/5, 82.5%/5, 87.5%/5). Muscle 13C-glycogen (CV 7.7%) was mean d13C ‰ (SD) -15.1 (1.4), -14.7 (1.2), -20.0 (2.3), while [glycogen] (µmol/mg dry) was 90 (41), 94 (81), 46 (41) for the two HI and LO trials. Fatmax with RATIO under LO was 1.73 g/min (0.26) at 93 %VO<sub>2</sub>max (10) compared with HI at 0.91 g/min (SD 0.23; HI-HI CV 14%) at 91 %VO<sub>2</sub>max (6.4). Similarly, Fatmax with IC in LO was 0.83 g/min (SD 0.21; HI-HI CV 76%) at 76 %VO<sub>2</sub>max (7.9) compared with HI at 0.38 g/min (0.18) at 71 %VO<sub>2</sub>max (8.3). Between LO-HI diets, RATIO revealed a greater difference in Fatmax rate (0.83 g/min; 95%CI 0.65–1.0) vs IC (0.46 g/min; 0.31–0.60), but Fatmax intensity was not changed by diet: RATIO 4.0 %VO<sub>2</sub>max (-2.5–11), IC 6.6 %VO<sub>2</sub>max (-0.1–13). In a confirmatory study, minute 13C-breath sampling and 10-min stage duration confirmed fat oxidation increases to plateau from 75% VO<sub>2</sub>max to ~100% VO<sub>2</sub>max.

The new RATIO method has acceptable reliability and revealed a fat oxidation rate plateau during intense exercise that is plastic diet. These findings refresh and challenge exercise metabolism paradigms for fat oxidation that may have implications in understanding energy provision within competitive sport and health.

## WHOLE BODY AND SKELETAL MUSCLE MAXIMAL FAT OXIDATION: BIOCHEMICAL THEORIES AND EVIDENCE

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UNIVERSITY OF COPENHAGEN

Endurance training promotes an upward and rightward shift of the fat oxidation during exercise across increasing relative exercise intensities and this is generally believed to potentiate longer duration endurance performance, through a relatively lower muscle glycogen utilization. In line with this major focus has over the last decade been specifically directed towards measuring maximal fat oxidation and understanding how and if maximal fat oxidation is linked to endurance performance. In studies of very trained people and elite athletes the Fatmax, the exercise intensity that elicits maximal fat oxidation, usually falls in the range of [60-70] % of VO<sub>2</sub>max, and this is clearly well below the exercise intensity at which endurance athletes compete. One of the key questions is thus how muscle fat oxidative capacity and whole body maximal fat oxidation are coupled and how this interplay influences exercise performance. This talk will focus on the biochemical theories and practical evidence that are key to the regulation of muscle and whole body fat oxidation.

## OP-SH08 PHYSICAL ACTIVITY PROMOTION / SOCIOLOGY GENDER

### NEGOTIATING AUTHENTICITY - A STUDY OF YOUNG EQUESTRIANS AND SOCIAL MEDIA

BROMS, L.

EDUCATION AND SOCIETY

Social Networking Sites (SNS) as for example Facebook (FB) has become a great part of everyday life of contemporary teens (Boyd, 2014). Research show that frequent FB users compare themselves to the perfect personas constructed on SNS which leads to a belief that other users are more successful than themselves even in their offline-lives (Vogel et al, 2014). Media studies show that there is a strong negative correlation between media coverage and a high proportion of female athletes. A likely explanation for the low coverage of equestrian sport is evidently that a majority of the riders are girls and women. Yet, new media habits in the era of digitalization, challenge our previous experiences of who and what is covered on SNS in relation to equestrian sports (Dashper, 2017).

In order to understand how online communication affects different groups in society, it is important to assemble information about online culture(s). Therefore, the aim of this study is to analyze young riders' use of SNS in relation to their everyday life around the horse, so as to identify cyber culture(s) connected to equestrian sport.

To understand young riders relations to SNS, Erving Goffmans theory impression management and the concepts Face-to-Face and Persona-to-Persona will be used (Goffman, 1959). The concept of authenticity and Judith Butlers theory regarding gender performativity (Butler, 1988) is used as a lens to analyze cultures emerging among riders on SNS. The empirical data has been collected through six focus group interviews at two Swedish equestrian centers. The population consist of 25 students (15 to 18 years).

This study shows that the image of the perfect equestrian life on SNS is governed by profiles using impression management, which ultimately leads to stress and anxiety among adolescents. Ideal images of super boys and girls in the cyber stable are created on SNS. The findings also show that the adolescents' relationship to SNS is complex. They admire- and compare themselves to riders who seem to be perfect athletes, at the same time they long to see a more authentic image of everyday life on SNS. It seems like the young equestrians are negotiating the concept of authenticity, constantly searching for content which break cultural barriers and challenge the idea of the perfect rider. Furthermore, they are negotiating gender constructions presented on SNS and question the ideal images of super girls and boys.

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### PROMOTION OF PHYSICAL ACTIVITY-RELATED HEALTH COMPETENCE IN PHYSICAL EDUCATION – RESULTS OF THE CLUSTER-RANDOMIZED GEKOS STUDY

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INTRODUCTION

The promotion of students' knowledge, skills and motivation to initiate and maintain a physically active lifestyle is a central goal of Physical Education (PE) in many countries (e.g., SHAPE, 2014). Physical activity-related health competence (PAHCO, Sudeck and Pfeifer, 2016) encompasses knowledge, attitudes, skills and competences which empower students to be physically active in a health-enhancing way. However, there is a lack of studies which investigate whether PAHCO can be promoted in PE. Therefore, this study aimed to examine the impact of two six week PE intervention programs for ninth graders on PAHCO compared to regular PE classes. Both PE intervention programs targeted health and physical fitness issues, combined practical as well as theoretical elements, and differed only in the type of physical activity (running and jumping respectively small-sided ball games) students had to perform.

#### METHODS

In total, 48 PE classes were randomly allocated to four different study groups: IG-run, CG-run, IG-game play and CG-game play. Altogether 841 ninth graders from secondary schools were tested pre-intervention, post-intervention and after 8-12 weeks follow-up. Students had to complete a health-related fitness knowledge test, as well as questionnaires on control competence for physical training, interest in physical fitness and health, and attitudes towards health effects of physical activity. Further, they participated in health-related physical fitness tests (Shuttle Run, standing long jump, sit-ups, push-ups). Differences in PAHCO between IG and CG at the post-test and follow-up were analysed considering nested data after adjusting for pre-test data with linear regression models.

#### RESULTS AND DISCUSSION

Health-related fitness knowledge, control-competence for physical training and students' endurance was significantly higher at post-test in the IG than in the CG ( $p < .05$ ). Also, health-related fitness knowledge maintained at a higher level at follow-up within the IG compared to the CG ( $p < .05$ ). Further analyses considering the impact of physical activity type, students' gender and students' interest in running and small-sided ball games will provide insights into differential effects of the intervention programs. In addition, results from the process analyses (e.g., monitoring of intervention delivery and intervention receipt) will be used for the interpretation of the final study results.

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### **HABITUAL FUSION: IDENTIFICATION OF INTERSECTIONS BETWEEN ADOLESCENT AND PARENTAL HEALTH GOALS TO INCREASE PHYSICAL ACTIVITY LEVELS IN ADOLESCENTS WITH POOR HEALTH BEHAVIOR.**

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UNIVERSITY OF HAMBURG

#### Introduction:

The prevalence of insufficient physical activity is rising consistently among adolescents (Abarca-Gómez et al., 2017). There is evidence that family health goalsetting increases the motivation of young people to improve their health behavior (Brown et al., 2016). As parental and adolescent health interests diverge (Colineau & Paris, 2011), this study focuses on identifying intersections of interests to increase physical activity levels in adolescents.

#### Methods:

A mixed-method approach has been applied. Qualitative sub-studies aimed at identifying family health goals, which is why N=60 parents (♂=25, ♀=35) participated in guideline interviews, and N=120 adolescents (♂=60, ♀=60) were interviewed in focus groups. The interview results were then evaluated with content analysis in MAXQDA. In the quantitative sub-study, N=1008 families were interviewed about their interest in the identified family health goals and their health behavior within a nationwide online survey. In a final step, the survey data was evaluated in SPSS using factor- and regression analysis.

#### Results:

In order to reduce the dimensions of family-health-goal-variables, both Bartlett test ( $\chi^2(435)=6267.828, p<.001$ ) and Kaiser-Meyer-Olkin measure (KMO=.879) indicated suitability for factor analysis, whereupon a 7-factor solution with 49% explained variance was adopted. Consequently, the initial variables were reduced to the factors nutrition, mindfulness, renunciation, organized activities, resilience, nature, and physical activity, whereby the factor accumulation of all family members showed that only the latter three factors represent a collective intersection. They were combined with the subjects health-behavior-index and integrated into a multiple regression model ( $F(3,956)=17,156, p<.001, Adj. R^2=.051$ ), which indicated that resilience ( $t=-.334, p<.001$ ), physical activity ( $t=(-5,647, p=.001)$ ) and nature ( $t=-3,035, p=.002$ ) are significant negative predictors of health behavior.

#### Discussion:

The results suggest that habitual fusion of family health goals is most likely within the dimensions of resilience, physical activity, and nature. The poorer the health behavior of families, the more likely they are to be interested in these factors. Even though this is an exploratory study, interventions that promote resilience of family members through collaborative outdoor activities could implicitly contribute to increasing physical activity among adolescents with poor health behavior.

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### **TACKLING CHILDREN'S PHYSICAL INACTIVITY IN LOW SOCIOECONOMIC AREAS WITH ALTERNATIVE SPORTS PROGRAMS. A BIOECOLOGICAL APPROACH.**

HÖGMAN, J., AUGUSTSSON, C., HEDSTRÖM, P.

FACULTY OF ARTS AND SOCIAL SCIENCES

#### Introduction

Alternative sports programs, providing activities beyond the conventional sport environments has been frequently utilized to reach inactive children, not at least in areas of low socioeconomic status. However, they have not been satisfactory examined whether they constitute constructive developmental environments from the perspective of the child. We suggest that programs need to be examined as a part of the ecological landscapes of childrens everyday life.

#### Methods



In order to grasp the complexity of physical activity behavior in children's daily lives we applied a bioecological perspective [1,2]. Physically active and inactive children in two rural and two suburban areas (n=63, ages 8-13) participated in 15 focus-group interviews. Inactive children (n=19) also participated in five separate focus-group interviews. Data was analyzed using qualitative content analysis informed by bioecological theory emphasizing interactions with the multidimensional environment.

#### Results

Findings reveal that the landscape in which children engage in daily PA consists of interconnected relations within the children's microsystems such as peer relations, child-adult relations, and child-environment relations and how these interact with both children's personal characteristics and factors at the mesolevel, exolevel, and macrolevel. This multileveled ecological landscape creates possibilities as well as barriers for children to engage in PA-related proximal processes. The everyday settings, such as organized activities provided by alternative sport programs, was considered as non-relevant to inactive children since participation in activities was not supported on all ecological levels. For instance, on a sociocultural level, the environments in which children were supposed to be physically active was marked by a conventional sports norm based on ideas that 'real' PA is the kind performed within organized sports.

#### Discussion

Applying the holistic perspective of bioecological theory makes visible that participation in alternative sports program activities requires supporting ecological landscapes. In order to increase physical activity levels among inactive children, programs need to be designed to fit the ecological landscapes of, not only active children, but inactive children as well. This may be achieved if social institutions cooperate and reflect on the movement cultures prevailing in these respective areas. For instance, they must accept that physical activities that inactive children may interact with might be different from the conventional ones.

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## OP-PN10 GENOMICS/MOLECULAR BIOLOGY

### DOES STRESSED LOCOMOTOR ACTIVITY ACTIVATE THE BRAIN DOPAMINE SYSTEM? A STUDY USING HPLC AND IMMUNOCYTOCHEMICAL ΔFOSB EXPRESSION ANALYSES

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#### INTRODUCTION:

Physical inactivity is a global health issue and increasing motivation for exercise habits is required. Although the neurotransmitter dopamine (DA) is involved in motivation, it is unclear how exercise can efficiently activate dopaminergic (DAergic) neurons, which are projected from the ventral tegmental area (VTA) to the prefrontal cortex (PFC). We reported that voluntary resistance wheel running with a load of 30% body weight (RW), which produces shorter running distances but higher work levels compared to wheel running without a load (W), enhanced muscular fitness and hippocampal memory functions [1]. This led us to postulate that rodents will try to run even during hard trials, thus maintaining exercise benefits to the hippocampus, probably due to activated DAergic neurons projected to the PFC. To test this hypothesis, we examined whether 4 weeks of RW would activate DAergic neurons in the VTA and increase their activity in the PFC using immunohistochemistry to examine ΔFosB expression in the VTA, a marker of neuronal activation, and HPLC (high performance liquid chromatography) analysis for DA metabolism in the PFC.

#### METHODS:

Ten-week-old Wistar male rats were used. Rats were assigned to a sedentary group (Sed), a wheel-running group without load (W), or a wheel-running group with a load corresponding to 30% of body weight (LW) for 4 weeks. Dopamine turnover rate (DOPAC/DA), a reliable indication of DA action, was assessed in the PFC dissected from the postmortem rat brain using HPLC. The activity of DAergic neurons was evaluated based on the number of double positive cells with TH (tyrosine hydroxylase, a DA marker) and ΔFosB (a marker for longer-term neuronal activation state) in the VTA using an immunohistochemical technique.

#### RESULTS:

Average work levels over the 4 weeks were significantly higher for the LW group than for the W group. The dopamine turnover rate was significantly increased in the LW group compared to the Sed group. The number of TH- and ΔFosB-positive cells in the VTA (activated DAergic cells) were higher in both the W and LW groups, although there was no significant difference between the two groups. Significant muscular hypertrophy was observed only in the LW group. There was significant correlation ( $r=0.89$ ) between work levels (running distance) and the number of FosB- and TH-positive cells.

#### CONCLUSION:

These results show a greater work levels and higher DAergic neuronal activation with LW, suggesting for the first time that resistance exercise can activate brain DAergic neurons. This implies that challenging exercise with a limited load stimulates the brain DA system, which may enhance motivation for physical activity.

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### MIR-29A, A NEW PLASMA BIOMARKER IN EXERCISE

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UNIVERSITY OF OVIEDO

#### INTRODUCTION:

MicroRNAs (miRNAs) are small non-coding RNA molecules, conserved between species. They can be found intracellularly, controlling gene expression, or circulating in biological fluids, as plasma, creating a crosstalk between tissues (1). miR-29 is a main regulator of glucose and lipid metabolism in skeletal muscle tissue (2). It also shows a clear interaction with PGC1- $\alpha$  (3) in cardiac muscle, regulating mitochondrial biogenesis and oxidative capacity. This highlights the potential role of miR-29 in the response to exercise. Several circulating miRNAs have been described to respond to acute exercise and training (4). However, the exercise response and the performance role of c-miR-29 was not studied. The aim of this study was to clarify the role of c-miR-29 as new biomarker in exercise.

#### METHODS:

Plasma samples were collected in fasted conditions from 30 young males: 10 sedentary (HSED), and 20 elite athletes (10 weightlifters ,HRES, and 10 long-distance athletes ,HEND). We had also taken basal plasma samples from 18 C57BL/6N mice, divided into three groups: sedentary (MSED), endurance training on a treadmill (MEND), and resistance training on a vertical ladder (MRES). The training design was 2 weeks of adaptation and 4 weeks of training, 5 days/week. Every session had fixed volumes, 1000m in MEND and 260mJ in MRES, but varying intensity. miR-29a expression was measured in plasma samples by qPCR. Raw data was pretreated by 2<sup>-</sup>(-ddct) method using exogenous miRNAs to normalize. One factor ANOVA was carried out to compare between groups. In order to analyze the role of miR-29 on performance, 8 C57BL6 knockout miR-29a/b1-/- mice (KO) and 8 wild type (WT) were used. Endurance and resistance maximal performance were tested by a treadmill ramp test protocol and a 10 repetition-maximum test, respectively. T-test for independent samples was used to compare exercise performance between KO and WT.

#### RESULTS:

Our results described an increment of c-miR-29a-3p in HRES and HEND vs. HSED (Fold Change +1). The same case was observed in mice, trained mice had higher level of c-miR-29a-3p compared with MSED (P<0.05). About performance, KO had a 50% lower performance in resistance test (P<0.01) and a 23% lower in endurance test (P<0.05) than WT.

#### CONCLUSION:

Based on data from Caravia et al.(3) and matched with miR-29a-3p validated targets(Tarbase), fatty acid metabolism pathway is clearly modified in KO: target genes were overexpressed and body fat was significantly lower than in WT (2,3). Taking into account these facts, exercise performance could be modified due to the fact that fat was not the main fuel for peak test performance.

All in all, miR-29a-3p can be proposed as a new exercise plasma biomarker and as a main determinant of fatty acid metabolism in exercise.

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### INFLUENCE OF FTO RS9939609 POLYMORPHISM ON APPETITE SENSATION AND ENERGETIC BALANCE IN YOUNG ADULTS.

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#### INTRODUCTION:

Single nucleotide polymorphism, rs9939609, within the FTO gene has been consistently associated with obesity by influencing food intake and impairing satiety in multiple populations. However, it has not been extensively studied whether exercise could play a role in the association between genetic variation in FTO and appetite. Therefore, our aim was to examine the association between FTO alleles and appetite before and after doing exercise which has been previously established as an appetite modulator. Additionally, we investigate whether energetic balance and body composition are influenced by FTO polymorphism.

#### METHODS:

Seventy-four young adults (28 females) were recruited for this study (22.6±4.2 yrs). Genotyping of the FTO rs9939609 gene polymorphisms (i.e. AA, AT, and TT) was performed by predesigned Life Technologies TaqMan® SNP Genotyping Assays (rs9939609, PCR). Visual analog scales were used for appetite sensations before and after an incremental exercise protocol until exhaustion. The energetic balance was calculated by the difference between daily energy intake and energy consumption. Daily energy intake was measured with a 7-day dietary record. Daily energy consumption was the sum of resting metabolic rate measured with a resting indirect calorimetry plus physical activity energy expenditure assessed using accelerometers which participants wore at the lower back during the same 7 consecutive days as the dietary record. Body composition was assessed through bioelectric impedance analysis in a fasted state. Due to the low numbers of AA homozygotes, the genotype was analysed with the use of the dominant-allele model, with A-allele being dominant (AA+AT vs TT). Differences between alleles were examined with analysis of variance with Bonferroni's correction.

#### RESULTS:

The genetic frequencies of our sample were AA+AT (63.5%) and TT (36.5%). No significant differences were found between A and T neither in anthropometric measures such as BMI (25.5±4.7 vs 26.3±7.0, p=0.5) or fat percentage (22.1±9.2 vs 25.1±10.8 p=0.2) nor appetite sensation before the incremental exercise protocol. The post-exercise sensations of hunger were significantly higher in TT than AA+AT participants (4.9±2.9 vs 3.3±2.5, p<0.02). Participants with the TT genotype had higher values of positive energetic imbalance (645.8±1333.7 kcals/day) than those with A allele (118.2±697.2 kcals/day) with significant differences (p<0.05). that remains after adjusting by fat and age.

#### CONCLUSION:

FTO polymorphism may exert an influence on appetite post-exercise, increasing the levels of hunger in the TT group. These results are consistent with previous studies and may suggest that TT people are more prompt to overeat after exercising and this could also explain the difference in energetic balance between alleles. Longitudinal studies are needed to clarify the effect of the FTO gene on appetite and body composition after a follow-up period.

## DYNAMICS OF HUMAN SKELETAL MUSCLE TRANSCRIPTOME CHANGES AFTER ENDURANCE EXERCISE: COREGULATED GENES AND UPSTREAM REGULATORS

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### INTRODUCTION:

Several studies investigated aerobic exercise-induced changes in human skeletal muscle transcriptome. However, dynamics of transcriptome are still unexplored. Adaptation of human skeletal muscle to regular exercise can reduce gene responses to acute exercise, which is associated with increasing specificity of these responses. We aimed to study the dynamics of skeletal muscle transcriptome in endurance-trained males after an aerobic exercise to identify coregulated genes and their upstream regulators.

### METHODS:

Ten young trained males performed an intermittent exercise [3 min, 50% of anaerobic threshold (AT) + 2 min, 100% of AT] x 12 on a cycling ergometer for 1 h. After high-intensity bouts, average oxygen consumption rate and lactate content in capillary blood were 85% of the maximum oxygen consumption rate and 5.5 mM, respectively. Biopsies from m. vastus lateralis were taken prior to, at 1, 3 and 6 h after exercise. Dynamics of transcriptome after exercise was evaluated using a cap analysis of gene expression (CAGE), which allows to accurately determine (to nucleotide) the transcription start sites (TSS). Upstream regulators were searched using the positional weight matrices (PWM) approach with two independent PWM databases (TRANSFAC and HOCOMOCO).

### RESULTS:

We found, that 330, 524 and 502 genes changed expression (>1.5 fold change,  $P_{adj} < 0.01$ ) at 1, 3 and 6 h after exercise, respectively, and >2/3 of these genes increased expression. Gene Ontology analysis showed that genes with increased expression were associated mainly with transcription regulation (at all time points) and with angiogenesis (at 1 and 3 h). While genes with reduced expression were significantly enriched (transcription regulation) only at 6 h. At 1 h after exercise, expression of genes encoding transcription factors (TFs) increased higher (by 20%,  $P < 0.05$ ) than that of other genes. Transcription factor mRNAs and proteins have short half-life (Schwanhauser et al., 2011). Hence, the transitory increase in the expression of TFs 1 h after exercise may play an important role in regulation of gene expression at later stages of recovery. The cluster analysis revealed 15 groups of coexpressed genes (genes with similar pattern of regulation). We identified the TSSs and defined a promoter region around each of TSS. Using the PWM approach, the most significant TFs whose binding motifs are enriched in the promoter regions of coexpressed genes were revealed: AP1 and CREB/ATF-related TFs, SP-related TFs, MAZ, EGR1, CENPB, NFKB1, E4F1 for clusters with upregulated genes, whereas WT1 and ZNF148 for clusters with downregulated genes.

### CONCLUSION:

In conclusion, for the first time we have characterized dynamics of transcriptome response in human skeletal muscle after an endurance exercise: clusters of coexpressed (coregulated) genes and TFs associated with various patterns of gene expression were identified. This work was supported by the Russian Foundation for Basic Research no. 17-00-00308K (17-00-00242) and no. 19-315-90135.

## OP-MH15 EXERCISE AND THERAPY

### EFFECTIVENESS OF A PHYSICAL ACTIVITY INTERVENTION USING WEARABLE TECHNOLOGIES IN IMPROVING BONE HEALTH IN PREMENOPAUSAL WOMEN. A RANDOMIZED CONTROLLED TRIAL.

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### INTRODUCTION:

Physical exercise is considered an effective means to stimulate bone osteogenesis in premenopausal women. However, not all activities or exercise modalities are equally osteogenic. In order to elicit an osteogenic effect, the mechanical load applied to bones should exceed that typically encountered during daily activities (Frost, 1988). Results suggest that bone tissue must be stimulated with loads exceeding a certain threshold to influence bone mineral density (BMD) in this population group (Jämsä et al. 2011). Thus, in order to develop effective protocols for osteoporosis prevention and to ensure skeletal integrity, exercise intensity must be objectively quantified and monitored. New technologies such as wearable accelerometers are increasingly being used to monitor exercise and assess mechanical loading in physical activities. However, studies using these devices to determine optimal loads for the bone remain few (Sañudo et al. 2017). The aim of the current study was to assess the effect of a lifestyle intervention based on physical activity using accelerometry-based technologies to estimate the intensity and frequency of the proposed activities.

### METHODS:

The trial was conducted over the course of 20 weeks. Sixty sedentary premenopausal women ( $41 \pm 5$  years;  $66 \pm 18$  Kg;  $165 \pm 7$  cm) were instructed to use a Muvone® accelerometer and a dedicated Muvone mobile app and were randomly assigned to two equally sized ( $N = 30$  each) groups: a) an experimental group that received feedback regarding the mechanical load of their physical activity and text messaging to encourage exercise (at least 10000 steps per day trying to reach 150 steps/min, as well as 60 impacts over 3.9g per day) and b) a control group that continued with their usual everyday activities but received no feedback regarding the mechanical load. Additionally, both groups had the opportunity to get information regarding their calcium intake. X-ray absorptiometry (DXA) was used to measure BMD of the trochanter and the femoral neck.

### RESULTS:

Fifty-five participants completed the intervention and repeated measured analysis revealed significant group by time interaction in and Trochanter BMD ( $F_{1,44} = 5.26$ ,  $p = 0.027$ , partial eta squared = 0.107-moderate) and Femoral neck BMD ( $F_{1,44} = 4.18$ ,  $p = 0.047$ , partial eta squared = 0.087-moderate).

### CONCLUSION:

In conclusion, behavior changes controlled by wearable technologies that require little time, cost or specialist equipment improved trochanter and femoral neck BMD in healthy postmenopausal women.

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### **MULTI-MODAL EXERCISE AS A DISEASE MODIFYING STRATEGY FOR PARKINSON'S**

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UNIVERSITY OF KENT

#### **INTRODUCTION:**

Parkinson's Disease (PD) is a complex and variable neurodegenerative condition. Due to its progressive nature and lack of effective treatments, a range of motor and non-motor symptoms develop and usually lead to disability and disengagement with active lifestyles. Exercise interventions have the potential of improving and sustaining physical and cognitive function in PD. Multi-modal (MM) exercise, that includes cognitive challenges, may be more beneficial than single modalities. However, research should investigate those outcomes concurrently and assess the long-term and underlying neuroprotective effects of MM exercise. Hence, a weekly community-based MM exercise session for PD was established to evaluate its effects on physical function, cognition and wellbeing outcomes over the period of 1, 2 and 3 years.

#### **METHODS:**

27 participants (EX group; 22 male, 5 female; age 64±8 years; Hoehn and Yahr (H&Y) scores≤III, indicating mild to moderate PD) attended a once-a-week MM group exercise session (60 minutes) for over one year. A battery of health and functional assessments were completed at the start and every four months for one (n=27), two (n=20) and three years (n=14). Those included: the six-minute walking test (6MWT), timed up and go (TUG), 1-minute sit-to-stands (STS) and bilateral grip strength (L-GS and R-GS). Additionally, a battery of cognitive function assessments plus Older People's Quality of Life Questionnaire (OPQOL-Brief) were measured. Results were compared to an aged-matched group of 20 healthy older adults (HOA group; 8 male, 12 female; age 61±6 years) and 20 non-active people with PD (na-PD group; 12 male, 8 female; age 68±7 years; H&Y scores≤III) to evaluate the rate of functional and cognitive decline in these groups.

#### **RESULTS:**

At baseline, no health-related between-group differences were observed. EX scores for 6MWT, TUG and GS did not significantly decrease across 1, 2 or 3 years, and the number STS increased during 1 year between baseline and after the first four months (from 20 to 23; P=0.001). Scores for CDT, TMT-A and B, and OPQOL-Brief did not change across four different assessments (i.e. 1 year). Interestingly, MMP increased between baseline and after 8 months (from 27.3 to 29.7; P=0.001). After starting the MM class, EX group's 6MWT scores were still lower than HOA (P<0.001) but TUG, STS and GS improved towards not being significantly different from HOA, whereas na-PD showed lower 6MWT, TUG and STS scores than HOA (P<0.000, 0.001 and <0.000, respectively).

#### **CONCLUSION:**

Our study shows that attendance at a once a week MM exercise for 1, 2 or 3 years, can maintain or improve physical and cognitive performance with no significant decline, especially for STS and MMP scores. These are positive outcomes given the progressive nature of PD. These findings contribute to the understanding of MM exercise as a neuroprotective and disease-modifying approach to slow down PD progression.

### **ACUTE EXERCISE IMPROVES IMMUNE-FUNCTION TOWARDS PROSTATE CANCER**

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#### **INTRODUCTION:**

Prostate cancer, due to the high level of heterogeneity and its immune suppressive character, responds poorly towards immunological treatments [1]. Exercise has long been known to substantially impact the immune system [2] and has been found to impact the risk for prostate cancer [3,4] to a yet unclear extend. Here, we investigate how one acute bout of exercise changes the response of the immune system towards prostate cancer.

#### **METHODS:**

20 newly diagnosed, early stage prostate cancer patients undergoing surgery performed one session of high intensity interval bike training (clinicaltrial.gov identifier: NCT03675529). Immune cell populations before, during and after exercise were evaluated by flow cytometry to monitor distribution, cytotoxicity and function, and utilized to measure the killing capacity against in vitro cancer cell lines K562, PC-3 and LNCaP. In addition, serum samples are used to conduct in vitro cancer cell incubation studies to identify the anti-tumoral effects thereof including underlying factors.

#### **RESULTS:**

Exercise has a profound effect on NK cell (6 fold), T cell (1-2 fold), CD8 T cell (2-3 fold) and NK like T cell (3 fold) mobilization to the circulation with increases in surface markers such as CD57 and Granzyme B on circulating CD8 T cells. Furthermore, peripheral mononuclear cells during exercise show increased killing capacity towards K562 cells (25±16% vs. 41±17%) and the prostate cancer cell line LNCaP (31±12% vs 55±18%), but not towards PC-3 cells (17±12% vs 18±12%) when compared to baseline values. Acute exercise serum will be utilized to evaluate a potential inhibitory effect on prostate cancer cell proliferation as proposed by others [5].

#### **CONCLUSION:**

Acute exercise elicits immune cell mobilization, resulting in increased surveillance and clearance of tumor cells within the circulation. However, the redistribution of mobilized immune cells after exercise cessation to the tumor-site needs to be established to improve the clinical benefit of these findings. This acquired knowledge of one exercise session can be translated to long-term training adaptations for cancer patients, helping to understand the molecular mechanisms linking exercise training to the reduced risk for prostate cancer.

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## EFFECTS OF EXERCISE TRAINING AFTER ESOPHAGECTOMY ON PHYSICAL FITNESS, QUALITY OF LIFE AND TREATMENT OUTCOMES IN PATIENTS WITH CANCER OF THE GASTROESOPHAGEAL JUNCTION – A FOLLOW UP OF PRESET STUDY

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### INTRODUCTION:

Treatment for cancer of the gastro-esophageal junction (GEJ) can result in considerable and persistent decrements of physical fitness and health-related quality of life (HRQoL). Accordingly, a strong rationale exists to design interventions aiming at maintaining physical fitness and HRQoL during treatment. We aimed to investigate feasibility and safety of postoperative exercise training for patients with cancer of GEJ.

### METHODS:

This follow-up of the PRESET pilot study (NCT02722785) included 49 patients with stage I-III GEJ cancer. The patients were allocated to postoperative exercise or usual care and followed for 1 year. The exercise group was prescribed 12 weeks of twice a week concurrent aerobic and resistance training. We evaluated the effects of exercise training on cardiorespiratory fitness, muscle strength and HRQoL. To assess safety, we recorded treatment outcomes including adherence to adjuvant chemotherapy, hospitalizations and 1-year overall survival.

### RESULTS:

The exercise group attended 69% of all prescribed sessions and improved muscle strength (+23.0 kg Leg press 1RM [95% CI, 12.4 to 33.5]) and cardiorespiratory fitness (+30.7 watt [95% CI, 16.3 to 45.1]). Only the exercise group had an improved HRQoL at 1-year follow-up (+14.9 points [95% CI, 4.5 to 25.3]). Exercise in the postoperative period was safe with no differences in rate of patients receiving adjuvant therapy 87.5% vs. 84.2% (RR 1.04 [95% CI, 0.74 to 1.44]), mean relative dose-intensity of adjuvant therapy 56.8% vs. 63.3%, rate of hospitalizations 36.8% vs. 26.1% (RR 1.41 [95% CI, 0.57 to 3.49]) or 1-year overall survival 80.0% vs. 79.3% (HR 0.87 [95% CI, 0.25 to 3.07]) for exercise and usual care, respectively.

### CONCLUSION:

Exercise in the postoperative period is safe and may improve HRQoL and physical fitness in patients with GEJ cancer. No differences in prognostic endpoints were observed.

## EXERCISE ADHERENCE AND EFFECT OF SELF-REGULATORY BEHAVIOUR CHANGE TECHNIQUES IN PATIENTS UNDERGOING CURATIVE CANCER TREATMENT: SECONDARY ANALYSIS FROM THE PHYS-CAN RANDOMISED CONTROLLED TRIAL

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### Background

Exercise is beneficial but often challenging for patients undergoing cancer treatment. Self-regulatory behaviour change techniques (BCTs) have been used in intervention studies to facilitate exercise in this population, but their effect on exercise adherence has not been evaluated. Furthermore, exercise adherence has been poorly described. This study aimed to provide a detailed description of exercise adherence according to the FITT-principles (frequency, intensity, time and type) and to determine the effect of self-regulatory BCTs on exercise adherence in patients participating in an exercise intervention during curative cancer treatment.

### Methods

This study used data from a Swedish multicentre RCT, the Phys-Can study. In total, 577 participants, recently diagnosed with early stage breast, colorectal or prostate cancer were randomised to high (HI) or low-to-moderate intensity (LMI) exercise, WITH or WITHOUT self-regulatory BCTs. The 6-month intervention consisted of supervised group-based resistance training twice a week and home-based endurance training. Self-regulatory BCTs included goal-setting, self-monitoring, action planning, review of behavioural goals and problem solving. Exercise adherence (i.e. performed/prescribed training) was assessed using attendance records, training logs and heart rate monitors, and was reported using descriptive statistics. Linear regression was conducted according to intention-to-treat.

### Results

For the groups WITH self-regulatory BCTs, participants attended on average 50% (HI) and 54% (LMI) of the resistance training sessions. They performed 47% (HI) and 56% (LMI) of all sessions with prescribed intensity (load), as well as 49% (HI) and 51% (LMI) of all sessions with prescribed time (repetitions). For endurance training, participants performed 36% (HI) and 54% (LMI) of total prescribed time at prescribed intensity.

For the groups WITHOUT self-regulatory BCTs, participants attended on average 52% (HI) and 54% (LMI) of the resistance training sessions. They performed 49% (HI) and 55% (LMI) of all sessions with prescribed intensity, as well as 51% (HI) and 50% (LMI) of all sessions with prescribed time. For endurance training, participants performed 40% (HI) and 48% (LMI) of total prescribed time at prescribed intensity.

The regression analysis revealed no effect of the self-regulatory BCTs on exercise adherence.

### Conclusion

An exercise adherence rate at about 50% for each FITT principle can be expected among patients taking part in comprehensive exercise interventions during curative cancer treatment. Our results also indicate that self-regulatory BCTs do not improve exercise adherence in interventions that provide structured support to all groups, such as supervised group sessions, feedback on exercise behaviour and social support. However, a more heterogeneous clinical population with lower motivation and exercise levels may benefit from self-regulatory BCTs, but this needs to be further investigated.

## OP-AP17 RUNNING/STRENGTH AND POWER

### FORCE-VELOCITY PROFILING IN ELITE ATHLETES: RELIABILITY AND AGREEMENT BETWEEN METHODS

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#### INTRODUCTION:

Force-velocity (FV) profiling has received increasing attention as means to monitor training adaptations and to serve as a basis for individual training prescription in athletes. The aim of the present study was to examine the reliability and agreement between methods for assessing individual FV-profiles of the lower limbs in national and elite athletes.

#### METHODS:

A total of 100 national to elite level athletes (male: n=83; female: n=17) participated in the present study (age 21±4 years). The athletes underwent physical testing twice before (pre) and after (post) 2-6 months of regular training and sport participation. The double pre and post measurements were separated by ~1 week. Individual FV-profiles were acquired from incremental loading protocols in the squat jump (SJ), countermovement jump (CMJ) and leg press (LP). Force plate and linear encoder were used for measuring force, velocity and power during SJ and CMJ. A linear regression was fitted to the average force and velocity values for each individual test to extrapolate the FV-variables: theoretical maximal force (F0), velocity (V0), power (Pmax) and the slope of the FV-profile (SFV). In addition, one repetition maximum (1RM) in back squat, 30-m sprint, and lean mass via Dual-energy X-ray absorptiometry (DXA) were measured.

#### RESULTS:

Regardless of strong linearity ( $R^2 > 0.95$ ) for individual FV-profiles, the SFV were shown to be unreliable for all measurement methods assessed during vertical jumping (coefficient of variation [CV]: 15-29%, intraclass correlation [ICC]: 0.14-0.78). Only the leg press exercise showed acceptable reliability of the four FV-parameters (CV: 4.3-8.8%, ICC: 0.87-0.97). For cross-sectional measures there was a large to nearly perfect agreement between measurement methods and equipment for F0 and Pmax (r: 0.50 to 0.91), while the correlations for V0 and SFV ranged from trivial to large (r: -0.27 to 0.61). For the change-data (pre to post), the FV-parameters showed mostly no agreement between methods and equipment with some trivial to large correlations for F0, Pmax and SFV (r: -0.41 to 0.65) but only trivial to moderate correlations for V0 (r: -0.38 to 0.45). The correlations among the FV-parameters and 1RM, 30-m sprint and lean mass ranged from trivial to very large for F0 and Pmax (r: -0.70 to 0.89), and from trivial to large for V0 and SFV (r: -0.61 to 0.61).

#### CONCLUSION:

Due to the poor reliability of the SFV and V0 obtained from vertical jumping, it is not recommended to use these measures for individual training prescription or interpreting training adaptations for athletes, regardless of measurement equipment. The reliability of FV-profiling can be markedly improved by including measurement points closer to the F0 and V0 intercepts, i.e by using exercises such as leg press. The poor ability to detect changes over time indicate that varying methods should not be used interchangeably.

### ACUTE WHOLE-BODY CRYOTHERAPY EXPOSURE 2HRS PRE-EXERCISE IMPROVES FACTORS OF ATHLETIC PERFORMANCE

PARTRIDGE, E., COOKE, J., MCKUNE, A., PYNE, D.B.

UNIVERSITY OF CANBERRA

#### INTRODUCTION:

Athlete preparation prior to competition or training is important for athletes to present in the best possible state of physical and mental readiness. Active and passive techniques can be utilised to potentiate short term benefits via neuromuscular facilitation (1). Whole-body cryotherapy (WBC) exposes users to temperatures of -110°C to -140°C for 1-3 min (1) to promote wellbeing and recovery for athletes (2). The aim of this study was to identify the optimal timing of WBC exposure enhancing athletic performance and perceived game readiness and overall wellbeing.

#### METHODS:

Well-trained male athletes (n=27; age: 24.1 ± 3.5 yr; mass: 92 ± 13 kg; height: 1.83 ± 0.07 m) participated in a multiple group cross-over design study. Each participant was exposed to a blinded single bout of WBC (-135 ± -6°C) or active control condition (-59 ± -16°C) either 1, 2 or 3 h prior to a series of maximal effort countermovement jumps (CMJ) recording mean velocity, power and jump height. Perceived game readiness and wellbeing questionnaires were completed using a 1-5 Likert scale survey pre-post intervention.

#### RESULTS:

There were moderate improvements in CMJ absolute power from baseline to 2 hr post-WBC exposure (5.3 ± 4.8%; ES 0.64 ± 0.45) but changes were unclear at 1 h (2.9 ± 10.9%, ES 0.03 ± 0.27) and 3 h (0.3 ± 1.8%, ES 0.06 ± 0.15) after WBC compared with controls. CMJ relative power was similarly increased from baseline to 2 h post-WBC (4.6 ± 4.5%, ES 0.37 ± 0.32). CMJ velocity exhibited small improvements across all three groups at 1 h (3.5 ± 5.1%, ES 0.15 ± 0.24), 2 h (4.9 ± 4.1%, ES=0.18 ± 0.30) and 3 h exposures (4.6 ± 4.5%, ES 0.26 ± 0.17). Changes in jump height were unclear in all three groups.

Muscle soreness 1 hr post-WBC exposure improved moderately (+1.1 ± 0.7 units), as did the overall game readiness survey score (+3.3 ± 2.3). Within the 2 hr post-WBC exposure group, small improvements were noted in stress levels (+0.5 ± 0.7) and overall survey score (+2.9 ± 1.6). Moderate significance was seen in muscle soreness (+1.3 ± 0.8,) and a large improvement in mental fatigue (+0.9 ± 0.4). The 3 hr post-WBC exposure group exhibited moderate improvements in self-reported muscle soreness (+2.9 ± 1.6, and overall game readiness survey score (+2.9 ± 1.6), and less mental fatigue (+0.6 ± 0.7).

#### CONCLUSION:

Pre-exercise WBC exposure can elicit small to moderate, transient improvements in mean velocity, relative and absolute power when used 2 hrs prior to exercise. Improving perceived muscle soreness, mental fatigue and stress levels could assist in preparing athletes to be in a heightened state of readiness prior to competition or training.

1. Bouzigon, R., et al. (2016). *J Therm Biol.* 61(2): 67-81.
2. Banfi, G., et al. (2010). *Sports Med.* 40(6): 509-17

## A PROPOSED TEST METHOD FOR ASSESSING THE MECHANICAL PROPERTIES OF TREADMILL SURFACES

COLINO, E., FELIPE, J.L., GARCÍA-UNANUE, J., GALLARDO, L.

UNIVERSITY OF CASTILLA-LA MANCHA

### INTRODUCTION:

The dynamic behaviour of the surface has the potential to significantly alter performance and biomechanics of athletes during sports practice. Thus, when comparing sporting performance on different surfaces, it is crucial to identify the degree of similarity between the surfaces themselves. Treadmill locomotion has been widely compared to overground locomotion over the years, and yet most of the studies did not report to which extent the mechanical properties of the treadmill surface reproduced those of the overground surfaces. Currently, no standardized method exists for assessing the mechanical properties of treadmill surfaces. Therefore, the aim of this study was to define a reliable and valid test method for assessing Shock Absorption (SA), Vertical Deformation (VD) and Energy Restitution (ER) in treadmill surfaces.

### METHODS:

Two treadmill brands (Technogym, Cesena, Italy; and Life Fitness, Rosemont, IL) were included in the study. For each brand, an old (>7 years) and a new (<1 year) model were assessed. The final sample consisted of 42 treadmills belonging to 4 different models: (a) Technogym Jog700 Excite (n=10), (b) Technogym Runartis (n=12), (c) LifeFitness Integrity Series 97T (n=11), and (d) LifeFitness Integrity Series DX (n=9). SA, VD and ER of the treadmill surfaces were measured by means of an advanced artificial athlete (AAA). Three different locations were assessed along the longitudinal axis of each treadmill, all from within the confines of the support area of the athletes. At each location, three drop tests were performed with the AAA, according to the test instructions for other sport surfaces.

### RESULTS:

In each location, our results show that the error assumed when using the data from the first drop test instead of the average of the second and third, as often recommended in the standards for other surfaces, is lower than the smallest changes that can be detected in the variables ( $SA \leq |0.06|$  %,  $VD \leq |0.04|$  mm, and  $ER \leq |0.16|$  %). Also, our results show the ability of the test method to detect meaningful differences between locations once the one-drop criterion is adopted.

### CONCLUSION:

Mismatches in surface stiffnesses are likely the most important – but also most neglected – variable that causes differences in running biomechanics between treadmill and overground conditions. In this sense, assuming equal mechanical properties for these surfaces may lead to inaccuracies in the interpretation of results and misleading research findings. Our study concludes that performing a single drop with the AAA in 3 different locations can be considered a representative and reliable method for assessing SA, VD and ER in treadmill surfaces. This may enable researchers, trainers and industry to compare treadmill and overground surfaces in a more accurate way, to gain knowledge about the quality of their treadmills, and even to adapt their mechanical properties to different purposes, ensuring that running on them mimic actual overground conditions as best as possible.

## IS-SH03 PERFORMANCE-ENHANCING DRUG USE IN SPORT: MOTIVATION, RATIONALIZATION AND INTERVENTION

### A MOTIVATIONAL AND SOCIAL COGNITIVE PERSPECTIVE ON ATHLETES' INTENTIONS AND BEHAVIOUR OF AVOIDING UNINTENTIONAL DOPING

CHAN, D.K.C.

THE EDUCATION UNIVERSITY OF HONG KONG

Doping refers to the violation of the anti-doping code of the World Anti-Doping Agency. It was often assumed that athletes who doped took performance-enhancing drugs on purpose. However, it has been reported that doping could also happen when athletes unintentionally took performance-enhancing substances on the banned list. The risk of unintentional doping indeed present in athletes' daily life, so athletes should be cautiously aware of the risk and actively avoid unintentional doping. In this presentation, I will present a series of studies that apply concepts of self-determination theory (Ryan & Deci, 2017) and the theory of planned behaviour (Ajzen, 1985) to demonstrate how motivation and social cognitive variables are linked to athletes' intention and behaviour of the avoidance of unintentional doping. The findings of these studies have eventually led to the development of a mobile health intervention that aims to strengthen athletes' intention and behaviour of the avoidance of unintentional doping. At the end of the presentation, I will provide a demonstration of the mobile health intervention and will present preliminary data about the intervention effectiveness.

### MORAL DISENGAGEMENT AND PERFORMANCE-ENHANCING DRUG USE: HOW ATHLETES RATIONALISE HARM TO THE SELF AS WELL AS HARM TO OTHERS

BOARDLEY, I.

UNIVERSITY OF BIRMINGHAM

Image and performance-enhancing drugs or methods (i.e., doping techniques) are prohibited in sport because they enhance performance, pose a risk to health, and/or contravene the spirit of sport. Given the inherent potential for health harms and/or ethical breaches, one may anticipate rationalisation to co-occur with doping. To scrutinize this supposition, this presentation will examine the relevance of six psychosocial mechanisms to the rationalisation of doping in sport and exercise contexts. These six mechanisms originate from Bandura's (1991) social cognitive theory of moral thought and action, and are collectively termed mechanisms of moral disengagement. First, a qualitative study showing evidence of moral disengagement in team- and individual-sport athletes who have used performance enhancing drugs will be covered. Next, a study that investigated a model of doping behaviour based upon Bandura's (1991) theory, examining the interrelations amongst empathy, self-regulatory efficacy, moral disengagement, anticipated guilt, and self-reported doping with sport and exercise participants will be presented. Finally, data from qualitative research showing evidence of moral disengagement in male and female bodybuilders who have engaged in harmful use of performance enhancing drugs will be covered. Collectively, these studies highlight the potential importance of moral disengagement for rationalising harm to the self as well as to others, and consequently the facilitation of image and performance enhancing drug use in sport.

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## **TRUE CHAMPION: AN EDUCATIONAL VIDEOGAME INTERVENTION FOR THE PREVENTION OF DOPING AND SUPPLEMENT ABUSE IN TEENAGE ATHLETES**

DUNCAN, L.

*MCGILL UNIVERSITY*

Adolescence is a developmental period during which attitudes, values, and decision-making skills are forming but are not yet fully mature. Thus, the early teenage years represent a critical developmental phase during which to implement values-based anti-doping interventions. Previous interventions have demonstrated efficacy in helping adolescents develop a pattern of cognitions and motivation that can protect them from initiating doping; however, they are limited by the considerable time and resources needed. Videogames provide a unique opportunity for hands-on learning via simulated role play that capitalizes on adolescents' predilection to experiential learning. Videogames can also be built around a set curriculum and be made available at low costs. I will present findings from the development and testing of True Champion, a values-based doping prevention videogame intervention. I will first present findings from a formative, qualitative, research phase in which data from adolescent and university-aged athletes was used to inform the development of the videogame intervention. I will then present the logic model that guided videogame development as well as an overview of the game objectives, content, and rules. Finally, I will present data from a randomized controlled trial with 284 athletes testing the efficacy of the True Champion intervention compared to a control condition on cognitions, motivation, and behaviours related to the prevention of doping in this population.

**13:00 - 15:00**

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## **PS-PL01 TENDON ADAPTATION TO MECHANICAL LOADING IN SPORTS, HEALTH AND DISEASE**

### **THE IMPACT OF LOADING AND UNLOADING ON HEALTHY AND INJURED HUMAN TENDON**

MAGNUSSON, P.

*BISPEBJERG HOSPITAL*

A tendon transfers force from the contracting muscle to the skeletal system to produce movement and is therefore a crucial component of the entire muscle-tendon complex and its function. The overall turnover of the tendon in humans seems to be taking place primarily within the first 17 years of life, indicating that the basic structure remains relatively unchanged through adult life. Yet, tendon tissue appears to respond to mechanical loading and unloading and the exact mechanism(s) of these reactions remains an enigma. We have explored structure and force transfer in tendon, and how tendons adapt to acute and habitual loading and unloading in health and injured tendons. We have also explored to what extent load magnitude influences the outcome in overuse injuries.

### **MECHANISMS OF HUMAN TENDON PLASTICITY – LINKS FROM MOLECULES TO CELLS TO ATHLETES TO PATIENTS**

SNEDEKER, J.

*UNIVERSITY AND ETH ZURICH*

Tendon tissue health very heavily depends on appropriate mechanical loading within a narrow, and still poorly defined, physiological range. The lecture will present an overview of tendon cell-matrix interactions that drive tendon tissue homeostasis, collagen matrix remodeling and eventually tissue degeneration. In addition, mechanically regulated signaling pathways will be discussed that may enable more effective treatment strategies to be developed.

Recent animal, human and cell culture experiments will be presented to provide novel insight into the molecular/mechanical triggers behind the tendon response to physical exercise. Focus will be given to current experiments that are clarifying how "overload" signals regulate tissue inflammation and cellular response to tissue damage. A collective picture is emerging, suggesting that tissue damage accumulates in the tendon until intrinsic repair mechanisms are overwhelmed. Specifically, the metabolic cost of extracellular matrix remodeling appears to exceed the locally available nutrient supply. In consequence, the tendon tissue may enter into a chronic disease state characterized by high matrix turnover and poor tissue quality. In this paradigm, a mechanically regulated balance seems to exist between recruitment and suppression of the extrinsic vascular system by resident tendon core cells. Upon injury or damage, this regulation in turn steers the tissue towards either functional remodeling or chronic tendon disease.

**15:00 - 17:00**

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## **OP-PN11 NUTRITION AND ERGOGENIC AIDS**

### **WHO RESPONDS TO A PLACEBO? FACTORS ASSOCIATED WITH RESPONSE TO PLACEBO DURING A DOUBLE-BLIND, RANDOMISED CONTROLLED TRIAL**

HURST, P., SAUNDERS, S., COLEMAN, D.

*CANTERBURY CHRIST CHURCH UNIVERSITY*

#### **INTRODUCTION:**

The placebo effect, a desirable outcome resulting from a person's expected and/or learned response to a treatment or situation, may significantly influence the interpretation of double-blind, randomised controlled trials (RCT). High placebo responder rates may under-



estimate the true efficacy of a treatment. It is therefore important for researchers conducting RCTs to be cognisant of factors influencing the placebo response. In this study, we performed a retrospective analysis of a RCT of participants' response to placebo beetroot juice on 5-km running performance.

#### METHODS:

Participants were 70 recreational runners (male 51.2%; mean  $\pm$  SD = age = 32.0  $\pm$  10.4 years, hours per week training = 6.16  $\pm$  3.98, 5-km personal best = 24:28 minutes:seconds). After completing measures of sport supplement use and their beliefs about sport supplements, participants completed 5-km time-trials at baseline and with the ingestion of nitrate depleted placebo (containing ~0.04 mmol of nitrate, Beet It Sport®). The smallest worthwhile change was calculated to identify placebo responders and backward linear regression identified variables associated with the placebo response.

#### RESULTS:

Nearly two-thirds of participants were identified as placebo responders (63%). Compared to baseline, time to run 5-km among placebo responders was 2.76  $\pm$  0.36%, whereas for non-responders it was -1.45  $\pm$  0.46%. Sport supplement use ( $\beta$  = -2.162,  $p$  = 0.042), sport supplement beliefs ( $\beta$  = -0.712,  $p$  = 0.034) and being male ( $\beta$  = -2.030,  $p$  = 0.022) predicted the response to placebo. Stronger beliefs about sport supplements also influenced the magnitude of improvement in 5-km times in the placebo condition compared to baseline ( $\beta$  = 0.820,  $p$  = 0.028).

#### CONCLUSION:

Results demonstrate that participants recruited to a RCT of beetroot juice on 5-km running performance were more likely to respond to a placebo if they used sport supplements, reported strong beliefs in their effectiveness and were male. Given that interpretation of RCTs can be influenced by the placebo effect, researchers using these research designs should consider measuring and controlling for these variables in their analyses. Further data on what may influence the response to a placebo is needed to help inform interpretation of RCTs.

### EFFECTS OF 7 DAYS OF BETROOT JUICE SUPPLEMENTATION ON MUSCLE CONTRACTILE PROPERTIES IN ELDERLY AND YOUNG INDIVIDUALS

COLOSIO, M., RASICA, L., BALDASSARRE, G., FERRI, A., MANFERDELLI, G., EASTON, C., BURLEIGH, M., MARZORATI, M., PORCELLI, S.

NATIONAL RESEARCH COUNCIL

#### INTRODUCTION:

Elderly people are characterized by muscle weakness due to an overall loss of skeletal muscle tissue, an impairment of excitation-contraction coupling and an intramuscular reduced sensitivity to Ca<sup>2+</sup> signaling. Moreover, aging seems to negatively affect plasma nitrate concentration [NO<sub>3</sub><sup>-</sup>]. Potential benefits of dietary NO<sub>3</sub><sup>-</sup> supplementation on skeletal muscle contractile function and muscle fatigue have been recently suggested. The mechanistic basis for these improvements seems to be related to skeletal muscle Ca<sup>2+</sup> handling. The aim of this study was to evaluate the effects of dietary NO<sub>3</sub><sup>-</sup> supplementation on muscle contractile properties in elderly subjects.

#### METHODS:

10 elderly (69 $\pm$ 4 ys, OLD) and 10 young (26 $\pm$ 2 ys, YG) individuals participated in a double-blind, randomized, crossover study. Participants consumed 140mL/day of either NO<sub>3</sub>rich beetroot juice (BR, 8.4mmol NO<sub>3</sub><sup>-</sup>/day) or placebo (PLA, with negligible NO<sub>3</sub><sup>-</sup> content), for 7 consecutive days. Evaluation of contractile properties of the triceps surae muscle complex was performed at the end of both periods of supplementation. Subjects completed the following set of measurements on the dominant leg using a customized ergometer: a) maximal voluntary contraction (MVC) of plantar flexion to estimate maximal voluntary force; b) resting and potentiated single twitches (Tw) and double twitches at the frequency of 100Hz (Db100) by maximal electrical nerve stimulation on the tibial posterior nerve; c) a fatigue test (FT) consisting in a prolonged isometric plantar flexion at 70% of MVC carried out until exhaustion. After few minutes of recovery, a force-frequency curve was assessed by stimulating the triceps surae of the non-dominant leg at 1-10-20-30-50-75-100 Hz. Resting plasma [NO<sub>3</sub><sup>-</sup>] and nitrite [NO<sub>2</sub><sup>-</sup>] from blood samples were measured by chemiluminescence.

#### RESULTS:

Preliminary results from 14 subjects (7 OLD and 7 YG) are reported. BR supplementation, compared to PLA, increased plasma [NO<sub>3</sub><sup>-</sup>] and [NO<sub>2</sub><sup>-</sup>] in both OLD (539.4 $\pm$ 119.3 vs. 32.3 $\pm$ 7.6  $\mu$ M,  $p$ <0.001 and 344.8 $\pm$ 165.1 vs. 81.9 $\pm$ 41.4 nM,  $p$ <0.05, respectively) and YG (554.4 $\pm$ 187.8 vs. 47.3 $\pm$ 8.8  $\mu$ M,  $p$ <0.01 and 260.7 $\pm$ 87.7 vs. 92.3 $\pm$ 26.4 nM,  $p$ <0.05). Interestingly [NO<sub>3</sub><sup>-</sup>] in PLA was significantly lower in OLD vs. YG ( $p$ <0.05). No changes were observed in MVC, Tw, and Db100 force after BR compared to PLA. FT time was significantly increased (about +25%) in BR vs PLA in both OLD and YG. In OLD, tetanic force significantly increased at stimulation frequencies higher than 20 Hz after BR (approximately +15%) vs PLA.

#### CONCLUSION:

Beetroot juice supplementation has potential beneficial effects on fatigue resistance and muscle force production at different frequencies of stimulation. Thus, the impairment in muscle contractile properties observed with aging can be positively affected by the increase in plasma concentration of nitric oxide precursors.

### DIETARY WOOL-DERIVED KERATIN PROTEIN IN COMBINATION WITH EXERCISE AUGMENTS GLUCOSE UPTAKE AND MUSCLE BLOOD FLOW IN ADULTS WITH TYPE 2 DIABETES MELLITUS – A RANDOMIZED CONTROLLED TRIAL.

PEETERS, W.M., GRAM, M., SHEARD, P.W., DANIELSON, K.M., DIAS, G., CORNWALL, J.E., ROWLANDS, D.S.

NEWCASTLE UNIVERSITY

#### INTRODUCTION:

We have successfully developed a protocol to process sheep wool into edible wool-derived keratin protein. Keratin is uniquely high in the amino acids cysteine, glycine, and arginine. Supplementation of these amino acids have been associated with improvements in glucose homeostasis and insulin sensitivity in T2DM. We therefore examined the effects of wool-derived protein in conjunction with exercise on glucose clearance rates (GCR) and skeletal muscle insulin sensitivity in T2DM.

#### METHODS:

In a double-blinded randomized trial, adults with T2DM (56.3 (8.3) y, HbA1c: 62, (13) mmol/mol) participated in a 14-week exercise intervention (mixed-mode high intensity endurance and resistance training 45 min/d, 5 d/wk) and ingested supplements immediately post-exercise and pre sleep. Total daily doses were 17 g wool-derived protein and 23 g whey protein (WDP,  $n$  = 11), 40 g whey protein (WHEY,  $n$  = 12) or an isocaloric placebo containing 18 g maltodextrin and 22 g gluten free flour (CON,  $n$  = 12). Glucose clearance rates (GCR) and muscle blood flow (mBF) were measured during a hyperinsulinaemic isoglycaemic clamp at weeks 0 and 15. Microvascular and myocellular

insulin signalling proteins eNOS/p-eNOSser1177, NOX2, p-IRS-1ser312, p-AS160thr642, p-PAK1thr423/p-PAK2thr402 and GLUT4 translocation were assessed from muscle biopsies in fasted and insulin-stimulated states at weeks 0 and 15 using Western blot or immunofluorescence.

**RESULTS:**

GCR increased (mean (SD) change, WDP: 1.8 (1.9), WHEY: 0.6 (1.0), CON: 0.7 (1.7) mL/kg/min) substantially in WDP compared to WHEY (29.4% 90%CI 0.5, 66.4) and CON (26.9% 90%CI -3.0, 64.1). Insulin-stimulated mBF increased (mean change (SD), WDP: 0.29 (0.20) WHEY: 0.08 (0.38), CON: 0.20 (0.20) mL/cm<sup>3</sup>/min) substantially in WDP compared to WHEY (45.7% 90%CI 9.0, 94.7) and CON (51.1% 90%CI 5.4, 116.6). Insulin-stimulated GLUT4 translocation increased (mean change (SD), WDP: 24.2% (29.8), WHEY: 11.6% (14.9), CON: 7.6% (26.5)) substantially in WDP compared to WHEY (14.9% 90%CI -1.2, 33.6) and CON (17.8% 90%CI -0.5, 39.4). Changes for GCR, mBF and GLUT4 between WHEY and CON were unclear. Changes in insulin-stimulated enzyme activity for eNOS, p-eNOSser1177, NOX2, p-AS160thr642 and p-PAK1thr423/p-PAK2thr402 showed no clear treatment effects, whereas p-IRS-1ser312 was substantially increased in WDP compared to WHEY (41.2% 90%CI 2.5, 94.6) and decreased in WHEY compared to CON (-17.0% 90%CI -35.8, 7.3).

**CONCLUSION:**

Study outcomes indicate that chronic post-exercise dietary protein type on insulin sensitivity in T2DM, dietary supplementation with WDP promoted clinically favourable insulin-sensitizing effects on whole-body and skeletal muscle tissue. In contrast, added effects of whey protein to exercise were unclear. These findings suggest a potential for digestible wool-derived keratin protein in clinical nutrition and possibly other instances where post-exercise protein ingestion plays a key role in supporting favourable musculoskeletal adaptations.

**DOSE RESPONSE OF DIETARY PROTEIN ON MUSCLE PROTEIN SYNTHESIS DURING RECOVERY FROM ENDURANCE EXERCISE IN YOUNG MEN**

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1: NUTRIM, MAASTRICHT UNIVERSITY MEDICAL CENTRE+, THE NETHERLANDS; 2: GATORADE SPORTS SCIENCE INSTITUTE, UNITED KINGDOM

**INTRODUCTION:**

Protein ingestion increases skeletal muscle protein synthesis rates during recovery from endurance-type exercise. The amount of ingested protein is a key factor determining the magnitude of the increase in muscle protein synthesis rate. We determined the effect of graded doses of dietary protein co-ingested with carbohydrate on whole-body protein metabolism, and skeletal muscle myofibrillar (MyoPS) and mitochondrial (MitoPS) protein synthesis rates during recovery from endurance-type exercise.

**METHODS:**

In a randomized, double-blind, parallel-group design, 48 healthy young endurance-trained men (age: 27±1 y, VO<sub>2</sub>peak: 58±1 mL/kg/min) received a primed continuous infusion of L-[ring-2H<sup>5</sup>]-phenylalanine, L-[ring-3,5-2H<sup>2</sup>]-tyrosine, and L-[1-13C]-leucine and ingested 45 g carbohydrate with either 0 (0 g PRO), 15 (15 g PRO), 30 (30 g PRO), or 45 g (45 g PRO) intrinsically L-[1-13C]-phenylalanine and L-[1-13C]-leucine labeled milk protein following a single 1.5 h bout of endurance-type exercise. Blood and muscle biopsies were collected during 6 h of post-exercise recovery to assess whole-body protein metabolism and both MyoPS and MitoPS rates. One-way repeated measures ANOVA with protein dose as between-subjects factor was used to evaluate between group differences in whole-body protein metabolism and muscle protein synthesis rates over the 6 h postprandial period, with Tukey post-hoc testing to locate specific differences.

**RESULTS:**

Protein intake resulted in ~72–74% of the dietary protein-derived phenylalanine to appear in the circulation. Whole-body net protein balance increased dose-dependently after ingestion of 0, 15, 30, or 45 g of protein (-0.31±0.16, 5.08±0.21, 10.04±0.30, and 13.49±0.55 μmol phenylalanine/kg/h, respectively; P<0.001). Ingestion of 30 g and 45 g PRO resulted in 46 and 52% higher MyoPS rates when compared with 0 g PRO (P<0.01). Ingestion of 45g PRO did not further increase MyoPS rates when compared with 30 g PRO (P=0.91). MitoPS rates were not significantly increased following protein ingestion, but incorporation of dietary protein-derived L-[1-13C]-phenylalanine into de novo mitochondrial protein had increased in a dose dependent manner following the ingestion of 15, 30, and 45 g protein at 6 h (0.018±0.002, 0.034±0.002, and 0.046±0.003 mole percentage excess, respectively; P<0.001).

**CONCLUSION:**

Protein ingested after endurance-type exercise is effectively digested and absorbed. Whole-body net protein balance and dietary protein-derived amino acid incorporation into mitochondrial protein respond to protein intake in a dose-dependent manner. Ingestion of 30 g protein is sufficient to optimize MyoPS rates during recovery from a single bout of endurance-type exercise in endurance-trained men.

**OP-BM12 NEUROMUSCULAR PHYSIOLOGY**

**MUSCLE STIFFNESS, FORCE DEFICIT, CALCIUM REGULATION AND FATIGUE AFTER MAXIMAL ECCENTRIC CONTRACTIONS**

HANDEGARD, V.1, LACOURPAILLE, L.2, GUILHEM, G.3, NORDEZ, A.2, SEYNNES, O.1, PAULSEN, G.1, RAASTAD, T.1

1 NORWEGIAN SCHOOL OF SPORT SCIENCES, OSLO, NORWAY 2 UNIVERSITY OF NANTES, FRANCE 3 FRENCH INSTITUTE OF SPORT, PARIS, FRANCE

**INTRODUCTION:**

Unaccustomed, maximal eccentric exercise induces a large stress on skeletal muscles and may lead to a transient state of fatigue and muscle damage. As a result, the maximal force-generating capacity of the muscles normally decreases by 20-50%. The mechanisms behind the reduced force-generating capacity comprise structural disruption of sarcomeres, increased permeability of the sarcolemma, and reduced efficiency of Ca<sup>2+</sup> release. This may lead to an accumulation of Ca<sup>2+</sup> in the cytosol, which in turn may cause increased muscle resting tension. Using shear wave elastography, recent studies have shown increased muscle stiffness acutely after eccentric exercise, and this stiffness was associated with reductions in voluntary force production. Although muscle damage may induce these changes in muscle stiffness, information about the confounding influences of fatigue, including Ca<sup>2+</sup> cycling, and change in voluntary drive is lacking. We aim to investigate the relation between neuromuscular fatigue, muscle stiffness, and muscle damage after high-intensity eccentric contractions. Further, we aim to investigate changes in Ca<sup>2+</sup> cycling and explore this in relation to muscle stiffness.

**METHODS:**

Participants (n=6) performed 50 unilateral eccentric biceps curls in a dynamometer. Prior to this work, muscle shear modulus (SWM), torque from maximum voluntary contractions during isokinetic actions (MVC, 30°/s) and electrically induced torque (n=5) at 20 and 50 Hz were assessed. MVC was performed 5 minutes, 3 and 24 hours after exercise. Electrical stimulation was performed between 1 and 3 hours post exercise. Muscle specimens were obtained at 2 hours after exercise. All measurements were performed on both arms and the contralateral arm served as control. A two-way ANOVA was performed for the MVC and SWM data, and a mixed-effects model was performed for the electrically stimulation data. Post-tests were performed when appropriate using Sidak's multiple comparisons.

#### RESULTS:

MVC was significantly decreased for the exercised arm at all timepoints after exercise (37-41%,  $p < 0.027$ ), whereas the control arm showed no effect of time (3-6%,  $p > 0.05$ ). Electrically evoked torque was significantly reduced at both 20 Hz ( $p = 0.0376$ ) and 50 Hz ( $p = 0.0002$ ) for the exercised arm and did not change in the control arm after the intervention ( $p > 0.05$ ). Further, post-exercise muscle SWM was increased in the exercised arm at 20 degrees elbow flexion ( $p = 0.0086$ ) only. Preliminary analyses indicate significant alterations in Ca<sup>2+</sup> handling systems.

#### CONCLUSION:

Maximal eccentric exercise of the biceps brachii increased muscle stiffness and decreased maximal voluntary force, and this coincided with decreased electrically evoked torque. We suggest that impaired Ca<sup>2+</sup> cycling explains these observations, and upcoming analysis of Ca<sup>2+</sup> cycling and fatigue will provide more information on relations between muscle stiffness, fatigue and alterations in Ca<sup>2+</sup> handling systems.

### ACUTE EFFECT OF OVERLOAD ON THE NEURO-MECHANICAL CONTROL IN DROP JUMPS AND DROP LANDINGS

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1 UNIVERSITY OF FREIBURG, 2 GERMAN SPORT UNIVERSITY COLOGNE, 3 UNIVERSITY OF APPLIED SCIENCES AACHEN, GERMANY, 4 UNIVERSITY OF PADUA, ITALY, 5 RENNBahnKLINIK, MUTTENZ, SWITZERLAND

#### INTRODUCTION:

Jumps and landings are fundamental elements of locomotion and are functionally relevant not only in most sport disciplines but also in daily activities. Both movement modalities require precise neuronal control of the skeletal muscles and subsequently involve either an efficient transfer (Drop jumps, DJ) or dissipation of energy (Drop landings, DL) (1,2). This study aimed to examine biomechanical and neurophysiological modulations during DJ and DL to investigate load-dependency of human movement during parabolic flights.

#### METHODS:

DJ and DL were performed in normal load (1g, NL) and overload (1.7-1.9g, OL). In 17 subjects electromyographic (EMG) activity of shank and thigh muscles were assessed before (PRE) ground contact (GC) and during the eccentric phase (ECC). Knee joint kinematics (2D) and GRFs were recorded to calculate loading rate (LR) and leg stiffness (LS). To compare the load dependent neuro-mechanical control of both movement modalities and to identify interaction effects a two-factorial rmANOVA (2x2; DJ/DL and NL/OL) was used for statistical analysis.

#### RESULTS:

In NL, DJ showed a higher EMG activity in PRE and ECC in the shank and thigh muscles compared to DL indicating task-specific muscle activation ( $p < 0.05$ ). This is accompanied by enhanced LR, LS and reduced knee excursion during GC in DJ ( $p < 0.05$ ). In OL, significant interaction effects between gravity and movement modality for PRE indicate enhanced muscular stiffness before GC in both DJ and DL ( $p < 0.05$ ). Interaction for ECC indicate reduced EMG activity in DJ, whereas DL show increased ECC EMG in OL. LR, LS and knee excursions are significantly increased in both DJ and DL in OL ( $p < 0.05$ ).

#### CONCLUSION:

Both movement modalities show task-specific muscular activation in NL characterized by high PRE and ECC EMG for DJ, whereas DL require less muscular stiffness in PRE and ECC to dissipate energy (3). During OL, neuromuscular control is adjusted in a phase specific manner (4). The enhanced neuromuscular stiffness before GC, for both DJ and DL, confirms the anticipatory capacity of the central nervous system to predict the amount of impact at GC (4) regardless of the movement modality. This is essential for providing joints and the muscle-tendon complex (MTC) with adequate stiffness to withstand increased loading rates during OL. In contrast, reduced task-specific differentiation between neuromuscular and biomechanical parameters during ECC indicates a similar motor control strategy in both movement modalities in OL. In DL, increased leg stiffness during ECC is needed to resist the greater loading rates by adjusting leg stiffness. Downregulated EMG in ECC accompanied by increased knee excursions are evidence of a more compliant MTC during DJ. This may represent a preventive strategy for protecting the MTC from surpassing the muscle tendon safety factors (5).

1 Komi, JBiomech, 2000

2 Linstedt et al., News Physiol Sci, 2001

3 Leukel et al., Hum Mov Sci, 2012

4 Ritzmann et al., JAppl Physiol, 2016

5 Biewener, JExp Biol, 2005

### NEUROMUSCULAR MODULATIONS IN ECCENTRIC EXERCISE-INDUCED MUSCLE DAMAGE AND THE REPEATED BOUT EFFECT

RUAS, C.V., LATELLA, C., TAYLOR, J., HAFF, G.G., NOSAKA, K.

EDITH COWAN UNIVERSITY

#### INTRODUCTION:

Unaccustomed eccentric (ECC) exercise results in muscle damage but confers protection from muscle damage, known as the repeated bout effect (RBE). However, the mechanisms underpinning the RBE are not fully understood. The present study investigated possible neuromuscular factors explaining smaller decreases in muscle strength after the second (ECC2) than the first bout of ECC (ECC1).

#### METHODS:

Six men and four women (26.2±5.0 y) with no resistance training experience, performed 6 sets of 8 ECC contractions of the knee extensors at 80% of ECC-1RM strength on an isoinertial leg extension machine in ECC1 and ECC2 separated by two weeks. Outcome measures were taken before, and 0, 24, 48 and 72 h after ECC1 and ECC2. Muscle soreness was rated on a 100-mm visual analog scale. Measures of knee extensor force included twitch force elicited by supramaximal femoral nerve stimulation, maximal voluntary isometric contraction (MVIC) force and rate of force development (RFD). Neural drive was assessed by voluntary activation (VA). EMG activity recorded from vastus lateralis included maximal M-waves (Mmax) and responses to single- and paired-pulse transcranial magnetic stimulation, namely motor

evoked potentials (MEPs) with the muscle at rest and contraction at 10-100% MVC, and short-interval intracortical inhibition (SICI: 3-ms interstimulus interval). MEP peak-to-peak amplitudes were normalised to Mmax. Two-way repeated measures ANOVA with follow up post-hoc and paired t-tests were used to compare the changes in the variables over time between ECC1 and ECC2.

#### RESULTS:

Muscle soreness was greater ( $P=0.01$ ) following ECC1 (peak:  $50.7\pm 31.8$  mm,  $P=0.001$ ) than ECC2 ( $27.5\pm 26.6$  mm). Twitch force decreased greater ( $P<0.001$ ) at immediately after ECC1 ( $-41.7\pm 3.0\%$ ) than ECC2 ( $-29.6\pm 8.8\%$ ), and returned to baseline at 48 h and 24 h post-ECC, respectively. MVIC force also decreased greater ( $P<0.05$ ) at immediately after ECC1 ( $-21.6\pm 23.3\%$ ) than ECC2 ( $-11.0\pm 11.3\%$ ) and fully recovered by 72 h post-ECC1 and by 24 h post-ECC2. RFD decreased at immediately after ECC1 (e.g. 0-50-ms:  $-50.5\pm 52.5\%$ ,  $P=0.01$ ), but did not decrease after ECC2 ( $P=0.28$ ). Decreases in VA ( $-11.7\pm 25.9\%$ ,  $P=0.007$ ) were similar immediately after ECC1 and ECC2, returning to baseline in 24 h. MEPs also decreased similarly after ECC1 and ECC2 (e.g. at 10% MVIC, 24h post-ECC:  $-23.3\pm 8.2\%$ ,  $P=0.009$ ; 72 h post-ECC:  $-30.5\pm 13.9\%$ ,  $P=0.003$ ). Mmax and SICI did not change after ECC1 and ECC2 ( $P>0.05$ ).

#### CONCLUSION:

The smaller changes in muscle soreness, twitch force, MVIC force and RFD after ECC2 than ECC1 indicate a RBE. The non-significant differences between ECC1 and ECC2 in VA and MEPs, and lack of changes in Mmax and SICI suggest little association of neural adaptations with the RBE. Therefore, the smaller decreases in MVIC force after ECC2 seem to be more associated with peripheral adaptations, which may be due to less disturbance of excitation-contraction coupling and force transmission system after ECC2 than ECC1.

## OP-AP18 FATIGUE/CYCLING

### TIME FOR ACTION: THE IMPACT OF FATIGUE, AND THE PRESENCE OF OPPONENTS, ON THE PERCEPTION OF TIME DURING A 4-KM CYCLING TRIAL.

MENTING, S.G.P., EDWARDS, A.M., HETTINGA, F.J.

UNIVERSITY MEDICAL CENTER GRONINGEN

#### INTRODUCTION:

The perception of time elapsed is known to vary in accordance with exercise intensity and stress (1). An accurate perception of time may be an important component of pacing during exercise (1). Research has shown that the perception of time is altered during individual endurance exercise at a fixed rate of perceived exertion (RPE) (1). However, further complexities during most sport scenarios include the increase of fatigue over the course of competition, while the presence of opponents also impacts pacing and performance (2). The purpose of this study is therefore to examine the impact of fatigue and opponents on the perception on time in response to exercise.

#### METHODS:

13 active healthy adults (seven females, six males) completed four, 4-km trials on a Velotron cycling ergometer. Participants were asked to specify when 30 seconds had elapsed, while chronologic time was simultaneously measured using a stopwatch. This task was performed before, during (pseudo randomized at either 500m, 1500m or 2500m) and two minutes after finishing the trial. Visit 1 was a familiarization trial (FAM). Visits 2 to 4 involved the following conditions, in randomized order: 1) cycle alone with the goal of setting the fastest time, 2) cycle alongside a virtual opponent (evenly paced, finish time: 105% of FAM) with the goal of beating the virtual opponent, 3) cycle alongside a virtual opponent with the goal setting the fastest time. RPE was recorded at the start of the trial, at two pseudo randomized moments during the trial (at 1-km, 2-km or 3-km), and directly after finishing the trial. A 3 x 3 repeated measurement ANOVA ( $p<0.05$ ) was used to examine differences in the perception of time pre-, during- and post-exercise, and between the three conditions. Two one-way ANOVAs ( $p<0.05$ ) were used to examine differences in the inter-trial perception of time and RPE over the course of the trials.

#### RESULTS:

Participants perceived time as slower during exercise ( $27.14\pm 6.71$ s) compared to pre- ( $31.78\pm 6.83$ s) and post-exercise ( $31.13\pm 7.48$ s) ( $F_2, 24= 4.99$ ,  $p=0.02$ ). There was no difference in the perception of time ( $F_2, 24= 0.15$ ,  $p=0.864$ ) between the conditions. RPE increased throughout the trials ( $F_4, 152= 271.70$ ,  $p<0.001$ ). There was no inter-trial difference in the perception of time ( $F_2, 4= 0.207$ ,  $p=0.814$ ).

#### CONCLUSION:

Time is perceived to move slower during exercise, compared to rest, indicating that participants felt it took longer than chronologic time. This indicates some education of time perception could be useful for accurate pacing. The perception of time returns back to pre-exercise level state after a short recovery period. An increase in perceived fatigue over the course of continued exercise, or the presence of an opponent, do not further impact the perception of time, indicating time perception may be based more on internal psychophysiological sensations of discomfort rather than extrinsic factors.

1. Edwards & McCormick. *Physiol Behav.*2017;180: 98-102.

2. Konings et al. *Physiol Behav.*2016;158: 1-5.

### PACING AND PERFORMANCE DURING THE WORLD 24-HOUR MOUNTAIN BIKE CHAMPIONSHIPS.

MATTA, G., MENTING, S.G.P., EDWARDS, A.M., HETTINGA, F.J., HURST, P.

CANTERBURY CHRIST CHURCH UNIVERSITY

#### INTRODUCTION:

Pacing is crucial for optimal performance in ultra-endurance events (1). This study investigated the impact of sex, category and athletes' performance capacity on pacing and performance during the World 24-hour Mountain Bike Championships.

#### METHODS:

Data from 837 men and 157 women in 8 editions of the race (2012-2019) were analysed. Athletes who covered more than two times the standard-deviation of the mean distance from each edition and completed more than 19.2 h (80% of total time), were included in the analysis. They were categorised based on age (e.g. under-23, 23-29, 30-34, 35-39, etc) or as elite and single-speed bike, and ranked into 5 performance-groups based on distance covered (i.e. groups 1 and 5 were the fastest and slowest clusters of athletes, respectively). Differences in performance between sexes were analysed using independent-samples t-test. Pacing was assessed by normalising the speed during the first, middle and last laps to the mean race speed and analysed with one-way repeated-measures ANOVAs. Differences in pacing between sexes, categories and performance-groups were analysed with two-way repeated-measures ANOVAs ( $P < 0.05$ ). Pearson correlations were used to calculate associations between normalised speed during the first-lap and total distance covered.

**RESULTS:**

Mean distance covered and final time were  $275.9 \pm 67.2$  km and  $23.7 \pm 1.1$  h, respectively. Men covered  $278.5 \pm 69.3$  km and women  $262.0 \pm 57.6$  km (5.9% difference;  $P = .005$ ). Elite athletes covered longer distances than all other categories ( $P < .001$ ), except for under-23 ( $P = .128$ ). Decreases in normalised speed from the first lap were found throughout all races ( $P < .001$ ). Significant interactions were found between pacing and categories, and performance-groups (both  $P < .002$ , Effect size [ES]  $> .022$ ), but not sex ( $P = .550$ , ES  $< .01$ ). Performance-group 1 adopted a slower normalised speed in the first lap in relation to groups 3-5 ( $P < .001$ ), and a higher speed in the last lap in relation to groups 4-5 ( $P = .010$ ). Correlations indicated an inverse moderate association between speed during the first lap and total distance covered ( $r = -.358$ ,  $P < .001$ ).

**CONCLUSION:**

Our results indicate that on average, athletes adopt a positive pacing strategy (i.e. decreasing speed from the first lap) during 24-hour mountain bike races. Men and women display similar pacing strategies, while performance was similar for elite and under-23 categories. However, faster athletes adopt a lower initial normalised speed, and a less pronounced decrease in the last lap, than slower athletes. This suggests that cyclists should adopt conservative initial speeds during the early stages of 24-hour mountain bike races to improve overall performance, although this may be dependent on experience, self-confidence and accurate knowledge of their performance capacity.

**REFERENCES:**

1. Abbiss & Laursen. *Sports Med*, 2008; 38: 239-252.

## IS-SP02 INDIVIDUALIZED FOOTBALL ATHLETES ASSESMENT TO ENHANCE PERFORMANCE AND TO REDUCE INJURY RISK - SPONSORED BY ADIDAS

### PHYSICAL DEMANDS IN ELITE FOOTBALL - IMPLICATIONS FOR TRAINING

MOHR, M.

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Elite football is an intense intermittent sport with frequent alterations between various activities of different exercise intensities and mode. The sport may be classified as a hybrid-activity where endurance exercise is "mashed-up" with short high intensity running bouts, power-based events demanding a high rate

of force development and discrete technical skills requiring coordination as well as randomly occurring cognition tasks. Thus, the physiological demands are multifactorial and cover majority of the main areas in the physical performance spectrum. Football match-play taxes both aerobic and anaerobic energy sources

shown by a high heart rate loading throughout a game, as well as moderately high blood and muscle lactate concentrations, as well as significantly degraded creatine phosphate stores during the most intense game-intervals. Fatigue has been demonstrated to occur temporarily during the peak intensity periods in a game, which may be associated with classical mechanisms such as disturbances in the muscle ion concentrations where ions such as  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{H}^+$  and  $\text{Cl}^-$  are plausible candidates provoking impaired muscle function. Moreover, a more cumulative type of fatigue accelerates in during the last phase of a game, which has been linked to low muscle glycogen concentrations in individual muscle fibres and subcellular compartments.

Low muscle glycogen content may negatively affect  $\text{Ca}^{2+}$  regulation in the sarcoplasmic reticulum and potential also  $\text{Na}^+ - \text{K}^+ + \text{ATPase}$  activity. Competitive football today is markedly more demanding than only few years ago with an increase in number games, as well as a markedly higher training volume. New scientific findings from several high-level research group have provided solid evidence of the superior effects of high

intensity training even if the training volume is compromised. Finally, studies have demonstrated large individual variability in game demands in top-class football. Thus, low volume high intensity training targeting the player-specific demands may be the solution to these challenges. In conclusion, elite football

imposed broad-spectrum physiological demands on the players. Moreover, these demands differ markedly between individual players, which calls for a player-specific fitness training approach where technical and tactical elements are integrated in the physical drills.

### PLAYER AND PERFORMANCE MONITORING OF FOOTBALL ATHLETES ON FIELD DURING TRAINING AND GAMEPLAY

MAHLER, H.

*ALBERT-LUDWIGS-UNIVERSITY OF FREIBURG / SC FREIBURG*

Performance monitoring in football by means of video or sensor technology is routinely and comprehensively used in training and match play. The main goal is to get a better understanding of the locomotor and physiological demands of training and gameplay in order to improve football specific fitness and to reduce injury risk [1]. However, frequently the scientific criteria have not been investigated sufficiently for the measurement technology, variables and analyzing approaches used in this context [2]. The purpose of this presentation is to discuss these aspects critically. Additionally, a new analyzing approach will be proposed [3], aiming to categorize peak intensity in relation to time duration in training and gameplay. In this framework the categorized performance will be discussed with regard to individual physical capacity and tactical instructions.

[1] Gabbett, T. J., Nassis, G. P., Oetter, E., et al. (2017). The athlete monitoring cycle: a practical guide to interpreting and applying training monitoring data. *Br J Sports Med* 2017, 0:1.

[2] Buchheit, M., & Simpson, B. M. (2017). Player-Tracking Technology: Half-Full or Half-Empty Glass? *International Journal of Sports Physiology and Performance*, 12(Suppl 2), S235–S241.

[3] Roecker, K., Mahler, H., Heyde, C., Röhl, M., & Gollhofer, A. (2017). The relationship between movement speed and duration during soccer matches. *PLOS ONE*, 12(7), e0181781.

**RETURN TO PLAY AFTER ACL RECONSTRUCTION IN FOOTBALLERS: TOWARDS AN OPTIMIZATION OF FUNCTIONAL OUTCOMES AND REDUCTION OF 2ND ACL INJURIES**

DELLA-VILLA, F.

ISOKINETIC MEDICAL GROUP

Anterior cruciate ligament (ACL) injury is one of the over-discussed topics in the worldwide Sport Medicine landscape. ACL reconstruction (ACLR) is globally considered as the gold standard for the football player who wish to return to full practice. Functional outcomes after ACLR have been studied widely in recent and past literature with two major concern being: 1) The sub-optimal return to play (RTP) rate, as low as 55% in competitive athletes [1] and 2) The high 2nd ACL injury rate in the young active patients, as high as 44% in young males at a long-term follow up [2].

Considering the amount of original research that have been produced on this injury and the major interest of the main stakeholders (from football teams to media and practitioners), the ACL injury is the perfect example of potential translational practice in our field.

With the goal of sharing our results and implementing in the day by day activity the best possible care to the patients and athletes, we built a rehabilitation based ACLR cohort of patients that we are studying prospectively.

Modifiable and non-modifiable factors related to RTP and 2nd ACL injury will be discussed to give the audience an overall picture of the best possible practice. As we believe that a greater focus should be put in the transition between return to training and return to match play, these aspects will be highlighted.

1. Ardern CL, Taylor NF, Feller JA, Webster KE. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta analysis including aspects of physical functioning and contextual factors. *Br J Sports Med* 2014;48:1543–1552.

2. Webster KE, Feller JA. Exploring the High Reinjury Rate in Younger Patients Undergoing Anterior Cruciate Ligament Reconstruction. *Am J Sports Med* 2016. Nov;44(11):2827-2832

**17:00 - 19:00****OP-PN12 CARDIOVASCULAR PHYSIOLOGY AND OXYGENATION****POST-EXERCISE ISCHEMIA REVEALS THE ROLE OF MUSCLE METABOLITE ACCUMULATION AND TISSUE OXYGENATION IN AUTOPHAGY ACTIVATION/DEACTIVATION IN HUMAN SKELETAL MUSCLE.**

MARTINEZ-CANTON, M., GALLEGU-SSELLES, A., MARTIN-RINCON, M., PEREZ-VALERA, M., MARTIN-RODRIGUEZ, S., SANTANA, A., GALVAN-ALVAREZ, V., MORALES-ALAMO, D., DORADO-GARCIA, C., CALBET, J.A.L.

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**INTRODUCTION:**

Although the mechanisms by which exercise activates autophagy remain unknown, high intensity, fatigue, hypoxia and high-energy turnover could be involved. This study aimed to ascertain whether intra-muscular acidification, Pi accumulation, and low PO<sub>2</sub> play a role in autophagy activation in human skeletal muscle. We hypothesized that autophagy would be activated depending on muscle energy levels, metabolite accumulation and PIO<sub>2</sub>.

**METHODS:**

Eleven men performed an incremental exercise to exhaustion (IE) in normoxia (Nx, PIO<sub>2</sub>:143 mmHg) and hypoxia (Hyp, PIO<sub>2</sub>:73 mmHg). At exhaustion, the circulation of one leg was instantaneously occluded (300mmHg) for 1 min. Muscle metabolites and AMPKa/ULK1/Beclin1, p62 and LC3B, were measured (Western Blot) in m. vastus lateralis biopsies, before (PRE), 10s after (POST, only occluded leg), and 1min after IE in the occluded (OC1M) and non-occluded (nOC1M) legs. Blood samples were drawn from the femoral vein and muscle tissue oxygenation measured by NIRS. Statistical analysis was performed using repeated-measures ANOVA.

**RESULTS:**

At POST, muscle PCr and ATP were decreased while Cr, lactate and H<sup>+</sup> were increased (Nx vs Hyp, P=NS). Femoral vein PO<sub>2</sub> was lower in Hyp (P<0.001). Occlusion reduced muscle oxygenation, impeded PCr recovery and increased acidification. The ratio pThr172/total AMPKa was increased 4.5-fold at POST, remaining elevated 3.8-fold above PRE in OC1M (both P<0.001), while it recovered close to basal in nOC1M. At POST, pSer555-ULK1 and the ratio pSer15/total Beclin1 were increased 1.6 and 2.0-fold, respectively, while LC3B was reduced by 24%. These changes were essentially maintained only in the occluded leg (OC1M vs PRE, P<0.01). The ratio LC3BII/I and p62 were reduced at POST and recovered 1min after IE in both legs. The IE elicited similar responses in signalling in Nx and Hyp.

**CONCLUSION:**

IE to exhaustion activates autophagy-signalling in human skeletal muscle with similar responses in Nx and Hyp, likely due to a similar metabolite accumulation at the end of both IEs. The increased acidification, reduction of tissue PO<sub>2</sub> and Pi accumulation during ischemia, did not activate autophagy further. The upregulated phosphorylations were reverted to PRE values after 1-min recovery with free circulation, coinciding with better oxygenation (NIRS), and nearly a 50% recovery of PCr. Thus, Pi is likely involved in the regulation of autophagy in human skeletal muscle. After one min of recovery with free circulation, muscle lactate and H<sup>+</sup> remained at the same level reached at exhaustion, indicating that neither high muscle lactate nor H<sup>+</sup> seem necessary to maintain autophagy activation. Our findings demonstrate that autophagy deactivation is extremely fast in human skeletal muscle. The FIO<sub>2</sub> during the exercise seems to play a secondary role since no additional activation of autophagy was observed at exhaustion in hypoxia compared to normoxia.

Grants: DEP2015-71171-R and DEP2017-86409-C2-1-P

## THE EFFECT OF ISCHEMIC PRECONDITIONING ON HIGH-INTENSITY CYCLING TIME-TO-EXHAUSTION, OXYGEN UPTAKE KINETICS, MITOCHONDRIAL FUNCTION AND PLASMA NITRITE IN ACTIVE MALES.

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SCHOOL OF SPORT, EXERCISE AND HEALTH SCIENCES

### INTRODUCTION:

The effect of ischemic preconditioning (IPC) on exercise performance is equivocal and the putative mechanisms that underly the potential ergogenic effect of IPC are unclear (Marocolo et al. 2019). Therefore, this study examined the effect of IPC on high-intensity cycling performance, pulmonary oxygen uptake ( $\dot{V}O_2$ ) kinetics, vastus lateralis (VL) tissue oxygenation and mitochondrial respiration variables and plasma nitrite ( $NO_2^-$ ) concentration ( $[NO_2^-]$ ) as a marker of nitric oxide production.

### METHODS:

With ethics committee approval eight active males ( $23 \pm 2$  y;  $\dot{V}O_{2peak}$   $52.7 \pm 7.0$  mL.min<sup>-1</sup>.kg<sup>-1</sup>) completed two experimental trials, in a counter-balanced repeated-measures design. Participants underwent contralateral IPC ( $4 \times 5$  min leg blood flow restriction + 5 min reperfusion) at 220 mmHg (EXP) or 20 mmHg sham (CON). After 60 min of rest, participants performed a cycling time-to-exhaustion (TTE) test at a power equivalent to 92% maximum work-rate ( $WR_{max}$ , determined from an incremental ramp test to exhaustion). The mean response time (MRT) of pulmonary  $O_2$  uptake kinetics was assessed during exercise and VL tissue oxygen saturation index (TSI) was assessed throughout the trials. VL muscle biopsies were obtained at rest and  $\sim 1.5$  min post-exercise and skeletal muscle fibres were permeabilised for assessment of mitochondrial respiration variables (Oxygraph-2k). Venous blood samples were obtained at rest, 1 and 45 min post-IPC and 1 min post-exercise and analysed for plasma  $[NO_2^-]$ . Data were analysed with two-factor repeated measures ANOVAs and post-hoc LSD  $t$ -tests, and are presented as mean  $\pm$  SD.

### RESULTS:

Mean TSI during the IPC protocol in EXP was lower compared to CON ( $46.3 \pm 5.2\%$  vs  $69.1 \pm 4.3\%$ ;  $p < 0.01$ ). There was no difference in TTE between CON and EXP ( $249 \pm 37$  vs  $240 \pm 32$  s;  $p = 0.62$ ).  $\dot{V}O_2$  MRT response time was faster ( $51.3 \pm 15.5$  vs  $63.7 \pm 14.5$  s;  $p < 0.01$ ) in EXP compared to CON, with no between condition differences in TSI ( $p > 0.05$ ). Coupled and peak respiration through mitochondrial protein complexes I-IV did not differ between CON and EXP ( $p < 0.05$ ). However, leak respiration was increased post-exercise compared with rest in CON ( $0.45 \pm 0.36$  vs  $0.73 \pm 0.36$  pmol.s<sup>-1</sup>.mg<sup>-1</sup>.CS<sup>-1</sup>;  $p \leq 0.05$ ) but not in EXP ( $0.49 \pm 0.2$  vs  $0.53 \pm 0.21$  pmol.s<sup>-1</sup>.mg<sup>-1</sup>.CS<sup>-1</sup>;  $p = 0.63$ ). Compared to baseline, plasma  $[NO_2^-]$  increased during IPC in EXP but declined during CON ( $+15.43 \pm 24.53$  vs  $-8.25 \pm 22.01$  nM,  $p < 0.05$ ). Plasma  $[NO_2^-]$  also increased 45 min post IPC in EXP compared with CON ( $+7.75 \pm 32.02$  vs  $-18.25 \pm 11.9$  nM;  $p < 0.05$ ).

### CONCLUSION:

IPC increased plasma  $[NO_2^-]$ , accelerated pulmonary  $\dot{V}O_2$  kinetics and prevented the post-exercise increase in leak respiration. However, IPC did not improve high-intensity exercise performance.

Marocolo et al. (2019), EJAP, 119, 2121-2149.

## CARDIOVASCULAR RESPONSES TO EXERCISE IN WOMEN WITH HEALTHY TWIN PREGNANCIES

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UNIVERSITY OF ALBERTA; WOMEN AND CHILDRENS HEALTH RESEARCH INSTITUTE

### INTRODUCTION:

In women with singleton pregnancies, it is well established that regular prenatal exercise provides significant benefits to maternal and infant health. However, current guidelines around the globe suggest limiting physical activity in women carrying twins. This conservative recommendation is not backed by empirical evidence and the safety of exercise in twin pregnancies remains unknown. The purpose of this study was to investigate the acute responses to aerobic exercise in twin pregnancies.

### METHODS:

A prospective comparison of maternal and fetal responses to submaximal cycling in women with singleton ( $n=10$ ,  $33 \pm 3$  yrs, pre-pregnancy body mass index [BMI]:  $26 \pm 5$ , gestational age:  $26 \pm 5$  wks) and twin pregnancies ( $n=10$ ,  $32 \pm 2$  yrs, pre-pregnancy BMI:  $27 \pm 8$ , gestational age:  $26 \pm 5$  wks: 9 di-chorionic/di-amniotic and 1 mono-chorionic/di-amniotic) was completed. Maternal cardiac function (heart rate [HR], cardiac output [CO], stroke volume [SV], ejection fraction [EF]; echocardiography) and mean arterial pressure (MAP; photoplethysmography) were measured at rest and during incremental cycling exercise to 70% HR reserve. Fetal HR (ultrasound) was measured pre- and post-exercise. The change ( $\Delta$ ) from rest to the highest equivalent workload (75 Watts [W]) was compared between groups (T-tests;  $\alpha=0.05$  was deemed significant). All data are expressed as mean  $\pm$  standard deviation.

### RESULTS:

In comparison to women with singleton pregnancies, women pregnant with twins had a higher resting HR ( $80 \pm 12$  vs.  $91 \pm 9$  bpm, respectively;  $P=0.04$ ) and CO ( $4.3 \pm 0.4$  vs.  $4.9 \pm 1.4$  L.min<sup>-1</sup>, respectively;  $P=0.02$ ), but similar SV ( $55 \pm 9$  vs.  $55 \pm 12$  mL, respectively;  $P=0.27$ ), EF ( $68 \pm 7$  vs.  $66 \pm 9\%$ , respectively;  $P=0.07$ ) and MAP ( $84 \pm 6$  vs.  $91 \pm 7$  mmHg, respectively;  $P=0.05$ ). In response to cycling exercise at 75 W, women with singleton and women with twin pregnancies had similar changes in HR ( $\Delta 60 \pm 7$  and  $\Delta 54 \pm 13$  bpm;  $P=0.19$ ;  $55 \pm 9$  and  $51 \pm 16\%$  HR reserve, respectively;  $P=0.48$ ), CO ( $\Delta 4.6 \pm 1.0$  vs.  $\Delta 3.0 \pm 2.1$  L.min<sup>-1</sup>, respectively;  $P=0.20$ ), and  $\Delta$ MAP ( $\Delta 19 \pm 8$  vs.  $\Delta 15 \pm 6$  mmHg;  $P=0.37$ ). Although not statistically significant, increases in SV (singleton:  $\Delta 13 \pm 12$  vs.  $\Delta 1 \pm 12$  ml;  $P=0.15$ ), and EF (singleton:  $\Delta 6 \pm 11$  vs.  $\Delta -2 \pm 11\%$ ;  $P=0.28$ ) during exercise appeared blunted in women with twin pregnancies. Fetal HR was unchanged in response to exercise at 70% HR reserve in both groups (singleton:  $\Delta -1 \pm 4$  vs. twin:  $\Delta 0 \pm 4$ ,  $P=0.53$ ), with no incidences of fetal bradycardia or tachycardia.

### CONCLUSION:

Healthy twin pregnancy was associated with a greater resting cardiac demand versus singleton pregnancies. As such, women pregnant with twins may have a lower cardiovascular reserve, as suggested by blunted increases in SV and EF during submaximal exercise. Nonetheless, no adverse impacts of submaximal exercise were observed in either maternal or fetal wellbeing. This study provides the first empirical data supporting the safety of acute, submaximal exercise for women with healthy twin pregnancies and is a critical first step towards developing activity guidelines for this population.

## IMPACT OF CATHETERIZATION ON SHEAR-MEDIATED ARTERIAL DILATION IN HEALTHY MEN

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### INTRODUCTION:

Animal studies have shown that endothelial denudation abolishes vasodilation in response to increased shear stress, reflecting the critical role of endothelial cells in the regulation of vascular tone. Interestingly, reduced but not abolished radial artery shear-mediated dilation has been reported in coronary artery disease (CAD) patients following endothelial denudation, raising the question of the extent to which shear-mediated responses are dependent upon an intact and functional endothelium in humans. However, it is not known whether this resulted from a priori endothelial dysfunction in this diseased population. Therefore, in this study we aimed to examine radial artery shear-mediated dilation following catheterization for first time in healthy, young trained males with a fully functional endothelium. It was hypothesized that shear-mediated dilation would be abolished or negative (vasoconstriction) following catheterization.

**METHODS:**

Twenty-six (age: 24.4±3.8 years, BMI: 24.3±2.8 kg.m<sup>-2</sup>, VO<sub>2</sub>peak: 50.5±8.8 ml/kg/min) healthy trained males underwent unilateral transradial catheterization. Shear-mediated dilation of both radial arteries was measured using flow-mediated dilation (FMD) pre, and 7 days post-catheterization. Differences pre-post catheterization and between the catheterized and control arm were determined using a mixed-linear model (SPSS 25). Data are mean±SD and significance P<0.05.

**RESULTS:**

FMD was reduced in the catheterized arm (9.3±4.1% to 4.3±4.1%; P<0.001) 7 days post-catheterization, whereas no change was observed in the control arm (8.4±3.8% to 7.3±3.8%; P=0.168). FMD was completely abolished (≤0%) in the catheterized arm in 5 and was <1% in a further 2 participants. Baseline diameter (P=0.001) and peak diameter during FMD (P=0.035) were increased in the catheterized arm 7 days post-catheterization (baseline: 2.3±0.3 to 2.6±0.2mm; P<0.001, peak: 2.5±0.3 to 2.7±0.3mm; P=0.001), with no change in the control arm (baseline: 2.3±0.3 to 2.3±0.3mm; P=0.288, peak: 2.5±0.3 to 2.5±0.3mm; P=0.608). Change in FMD in the catheterized arm, after accounting for the change in the control arm, was not correlated with the baseline diameter (r=0.300, P=0.164), catheter size (r=-0.179, P=0.413), artery-to-sheath ratio (r=0.291, P=0.177) or with participants' age (r=0.217, P=0.320), BMI (r=-0.244, P=0.263) or VO<sub>2</sub>peak (r=0.344, P=0.108).

**CONCLUSION:**

This is the first study to provide direct evidence of impaired shear-mediated dilation following catheterization in young trained individuals with fully intact a priori endothelial function. Abolition of FMD in one-fifth of participants suggests that the endothelium plays an essential role in shear-mediated dilation in healthy individuals. When combined with earlier studies in CAD patients, where FMD was impaired but not abolished, our data suggests the endothelial contribution to FMD may be larger in healthy, well-trained individuals than in subjects with a priori endothelial dysfunction.

### EFFECTS OF HEAT ACCLIMATION AND HYDRATION STATUS ON LEFT VENTRICULAR VOLUMES AND SYSTEMIC HAEMODYNAMICS DURING REST AND EXERCISE IN HUMANS

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ASPETAR AND BRUNEL UNIVERSITY LONDON

**INTRODUCTION:**

Heat acclimation (HA) may enhance cardiac output (Q) during submaximal exercise in the heat through an elevation in stroke volume and decrease in heart rate (HR; 1). Increased cardiac filling time and blood volume (BV) have been proposed to improve the diastolic filling of the left ventricle (LV) during HA (1,2). However, this hypothesis has never been tested. Furthermore, the influence of exercise-induced dehydration (DEH) on LV volumes in heat acclimated humans remains unknown. We therefore determined the effects of HA and hydration status on LV volumes and systemic haemodynamics during rest and exercise to gain further insight into the mechanisms underpinning the cardiovascular responses to HA.

**METHODS:**

Eight trained males completed two trials of prolonged submaximal exercise in the heat (33°C and 50% RH) while maintaining pre-exercise euhydrated body mass (EUH; -0.6±0.4%) or becoming progressively DEH (-3.6±0.7%). Rectal (Tre) and skin temperature, LV volumes, systemic haemodynamics and BV were measured at rest and during discontinuous bouts of semi-recumbent cycling (55% VO<sub>2</sub>max) at 20, 100 and 180 min. Bouts were interspersed by periods of upright exercise and measurements of nude body mass. Trials were repeated following 10-days of exercise HA with hydration status standardised via individualised fluid intake. A three-way repeated measures ANOVA was performed to determine the effects of HA and hydration status on thermal and cardiovascular parameters during exercise. All data are mean ± SD.

**RESULTS:**

Tre, BV, HR, LV volumes and systemic haemodynamics were similar among the 4 trials at rest and after 20 min of exercise, when participants were still euhydrated (all P>0.05). These responses were also largely unaffected by HA at 100 and 180 min in either hydration state. However, DEH was consistently associated with a lower stroke volume (22±8 ml), end diastolic volume (26±12 ml) and Q (1.9±0.8 L/min), and greater elevations in Tre (0.6±0.3°C) and HR (14±7 beats/min) compared to EUH after 180 min (all P<0.05).

**CONCLUSION:**

HA has no or minimal effects on LV volumes and systemic haemodynamics at rest and during discontinuous bouts of semi-recumbent submaximal exercise in the heat, where HR and BV are similar. In contrast, DEH beyond ~3% of body mass is associated with hyperthermia, elevated HR, reduced BV and a decline in the diastolic filling of the LV, which impair Q, regardless of HA state. Together, these findings indicate the cardiovascular system is highly responsive to stress evoked by acute DEH, but is largely unaffected by exercise HA when HR and BV are not altered.

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### CEREBRAL HAEMODYNAMIC AND NEUROTROPHIC RESPONSES TO CONTINUOUS AND INTERVAL-BASED EXERCISE

WEAVER, S.R.1, SKINNER, B.D.1, FURLONG, R.1, LUCAS, R.A.I.1, CABLE, N.T.1, RENDEIRO, C.1, MCGETRICK, H.M.2, LUCAS, S.J.E.1,3

UNIVERSITY OF BIRMINGHAM

**INTRODUCTION:**

Exercise-induced improvements in cerebrovascular function are thought to be associated with increases in blood flow and release of neurotrophic factors linked to vascular adaptation. Whilst interval-based exercise interventions have shown similar, or superior, improvements



in peripheral vascular function compared with steady state activity, little is known about their impact on brain blood flow. This study aimed to a) investigate the impact that interval-based exercise protocols have on acute cerebrovascular response, and b) determine the effect of these protocols on the release of neurotrophic factors, compared to a continuous exercise protocol.

#### METHODS:

24 participants (9 female; 23 ± 5 years; VO<sub>2</sub>peak 43.9 ± 6.7 mL/kg/min) completed three cycling-based exercise sessions in a randomised crossover design. Exercise sessions involved: 1) 30-min (65% VO<sub>2</sub>peak) of steady-state exercise (MICT); 2) clinical-guideline-based high intensity interval exercise (HIIT) – 4x4-min intervals at 85% HRmax, separated by 3-min active recovery (50 W), and 3) sprint-based interval exercise (SIT) – 4x30-s intervals at 200% Wmax, separated by 4.5-min active recovery. Continuous middle cerebral artery velocity (MCAv) was recorded, with 30-s averages taken at rest, during exercise, and active and passive recovery. Blood samples were taken at rest, end of exercise, and active (3 min) and passive (15 min) recovery. Obtained plasma was analysed for vascular endothelial growth factor (VEGF), brain-derived neurotrophic factor (BDNF), insulin-like growth factor 1 (IGF-1).

#### RESULTS:

MCAv increased during MICT (>16%, p<0.05) and across all HIIT bouts (>18%, p<0.05), with a greater increase for HIIT bout 1 compared to MICT (28 ± 18% vs. 19 ± 15%, respectively, p<0.05) and HIIT bout 2 (19 ± 15%, p<0.05). For SIT, the increase in MCAv during bout 1 (27 ± 22%) was greater than MICT (p<0.05) and similar to HIIT bout 1 (p=0.60). Subsequent SIT bouts were lower than MICT and HIIT bouts, with only SIT bout 2 significantly elevated from rest (9 ± 17%, p<0.05). VEGF was significantly increased in SIT alone, with increases seen following end of exercise (25 ± 19%, p<0.05) and active recovery (31 ± 21%, p<0.05). Similarly, both BDNF and IGF-1 were elevated at end of exercise and active recovery in SIT alone (BDNF: 127 ± 210% and 117 ± 110%; IGF-1: 23 ± 26% and 39 ± 47%, all p<0.05 vs rest), remaining elevated in BDNF following passive recovery (91 ± 20%, p<0.05). No significant changes were seen with MICT (BDNF: 55 ± 78%, IGF-1: 2 ± 13%) or HIIT (BDNF: 43 ± 41%, IGF-1: 8 ± 17%) from rest.

#### CONCLUSION:

Whilst MICT and HIIT appear to be more effective in stimulating acute increases in MCAv, SIT resulted in significant increases in key neurotrophic factors linked to cerebrovascular health. This indicates that SIT may be capable of driving chronic adaptive training responses in the brain, despite comparatively smaller increases in cerebral blood velocity.

## Invited symposia

### IS-BM01 MODERN METHODS ASSESING NEUROMUSCULAR CONSEQUENCES OF AGEING AND TRAINING

#### NEUROMUSCULAR CONSEQUENCES OF AGING AND NOVEL TRAINING METHODS TO COUNTERACT DETERIORATION

VAN ROIE, E.

KU LEUVEN

Power and rapid force production decline at a greater rate during ageing and are more relevant for functional deterioration than either loss of maximum strength or muscle mass. Different methodologies to examine these components of neuromuscular function exist, ranging from protocols including isometric, dynamic concentric and more functional stretch-shortening cycle muscle actions. Although all seem to evaluate similar components of neuromuscular function, they do have the potential to provide distinct information and that should be taken into account when choosing the appropriate assessment tool. In addition, researchers should reflect on clinically feasible measures of power that allow large-scale implementation.

To counteract functional deterioration in the aged, recent insights have justified the inclusion of explosive type of resistance exercise. Machine-based resistance exercise performed with an explosive type concentric phase followed by a controlled, slower eccentric phase is currently recommended in older people to optimize functional gains. As human movement typically consists of stretch-shortening cycle (SSC) actions (e.g. climbing stairs) instead of pure concentric movements, plyometric exercises targeting these multi-joint SSC actions should resemble daily function even more. However, it is unclear whether older adults can sustain such high-impact training.

This session stresses the need for integrating measures of lower-body power in geriatric assessments and highlights important testing considerations to assess specific aspects of neuromuscular function. In addition, the benefits, program considerations and safety features of explosive type of resistance exercise, including plyometrics, in older people are unraveled.

#### THE INFLUENCE OF AGEING AND EXERCISE ON HUMAN MOTOR UNIT STRUCTURE AND FUNCTION

PIASECKI, M.

UNIVERSITY OF NOTTINGHAM

Lifelong exercise has proven to offer a range of benefits in older age with Masters Athletes representing a niche, and somewhat extreme population in which the effects of ageing may be examined independently of the commonly associated reductions of physical activity. Older muscle may be generally characterised by fibres that are smaller and fewer in number, and are comprised of motor units (MU) that are also fewer in number but due to cycles of denervation and compensatory reinnervation, are larger in size. Whilst it is clear the effects of age cannot be prevented; multiple independent findings have supported the role of exercise in attenuating age-associated decrements of neuromuscular function, inclusive of exerting localized effects on MU remodeling. This talk will address current and developing methodologies that are employed to investigate individual MU structure and activity and the relationship to clinically relevant functional parameters, and will demonstrate recent findings on the plasticity of the peripheral motor system in response to external stimuli.

**CORTICAL PROPRIOCEPTIVE AND MOTOR FUNCTIONING AFTER RESISTANCE TRAINING IN OLDER INDIVIDUALS**

WALKER, S.

UNIVERSITY OF JYVÄSKYLÄ

Although measuring cortical activity via EEG and other imaging techniques has been performed for some decades, there is increasing interest (specifically in motor control research) in high-temporal and spatial resolution methods such as magnetoencephalography (MEG). While there are various approaches, one topic of interest is determining modulation in oscillating frequencies. In particular, beta-band frequencies (~15–35 Hz) appear to have potentially functional relevance to motor control. At least this seems to be modulated by force level (Fry et al. 2016) and acute fatigue (Fry et al. 2017). Another promising method is to determine the frequency correlates between the cortex and movement (kinematics). This corticokinematic coherence has shown promising accuracy and reliability to be used as a test measure for motor control research (Piitulainen et al. 2018).

Recent work in our lab has investigated the impact of aging and strength training on cortical proprioception and voluntary activation using MEG. A custom-built MEG-compatible chair has been implemented in these studies to answer questions related to motor control. Firstly, passive ankle rotations have been implemented with sustained rotations at 2-Hz (4 min recording) or inducing ~75 intermittent, rapid (~200°/s) dorsiflexions to elicit a stretch-reflex in the triceps surae muscles. These tests were performed in untrained young (18-30y) and older (65-75y) subjects before and after a 14-week strength-training program. Secondly, rapid voluntary plantarflexion actions to 15 and 50% MVC were tested in a group of strength-trained older men (75y; 10 years supervised strength-training begun at ~65y) versus untrained age-matched controls.

In passive conditions, slow/rhythmical movements of the ankle at 2-Hz showed greater corticokinematic coherence in older than in young adults for both the dominant and non-dominant leg. This suggests that older adults require greater cortical processing of the proprioceptive information compared to young. Rapid stretching led to the expected initial decrease in beta-band power followed by its rebound. Nevertheless, older adults showed greater reductions after the stretch, a consequence of higher baseline beta-band power compared to young. This was observed in both legs and may indicate greater resting cortical inhibition in older that must be overcome to enable an appropriate motor response. Short-term strength training did not alter the cortical responses to rapid stretching.

It appears that the techniques that my group has developed is able to identify activation differences within the cortex between groups that may help to explain degradation due to aging. In future, through these and other group's studies we will gain further insight into cortical response to/control of movement that can be applied to e.g. sports, exercise and medical fields.

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**OP-AP19 TEAM SPORTS/MONITORING AND EVALUATION****DEVELOPMENT OF A TRAINING QUALITY ASSESSMENT TOOL**

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1: UNIVERSITY OF TECHNOLOGY SYDNEY, SYDNEY, AUSTRALIA, 2: AUSTRALIAN INSTITUTE OF SPORT, CANBERRA, AUSTRALIA, 3: NEW SOUTH WALES INSTITUTE OF SPORT, SYDNEY, AUSTRALIA, 4: UNIVERSITY OF CANBERRA, CANBE

## INTRODUCTION:

Training is closely monitored by sport science practitioners and coaches, with load categorised as either internal or external. Traditional training monitoring tools provide indication of changes in training and fatigue status, however they do not directly assess an athlete's training quality. Training quality is an important concept, in which athletes strive to achieve optimal training outcomes. Assessment of training quality may provide insight to various aspects of training, instead of priority given to physical capacities. Therefore, this study aimed to develop and validate a subjective scale of training quality.

## METHODS:

The Subjective Training Quality (STQ) scale was comprised of three questions regarding physical, technical and mental training constructs. A purposive sample of 252 sub-elite to elite athletes, across eight team and individual-based sports completed the STQ scale. Cronbach's alpha ( $\alpha$ ) was used to assess internal consistency, and histogram plot analysis assessed face validity. Confirmatory factor analysis (CFA) compared the physical, technical, and mental constructs, and rating of perceived exertion (RPE), with training quality. Root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR) evaluated CFA quality of fit.

## RESULTS:

Physical, technical, and mental constructs demonstrated strong internal consistency ( $\alpha=0.85$ ) and excellent face validity. Inclusion of RPE reduced the internal consistency of training quality ( $\alpha=0.73$ ). CFA quality of fit was excellent (RMSEA=<0.01 "excellent", SRMR=0.00 "perfect"), and decreased with inclusion of RPE (RMSEA=0.088 "mediocre", SRMR=0.01 "good").

## CONCLUSION:

The STQ scale demonstrates excellent internal consistency and face validity, establishing capacity to assess training quality. Inclusion of RPE reduced internal consistency and quality of fit, therefore it is inappropriate to use RPE to infer training quality. Further investigation is required to determine how the STQ scale may interact with subjective and objective training performance measures, and how it could be incorporated into daily training monitoring.

**INSTRUMENTATION IN SPORTS RELATED CONCUSSION: PROPOSING INERTIAL WEARABLES AND OUTCOMES AS OBJECTIVE TOOLS**

POWELL, D., STUART, S., GODFREY, A.

NORTHUMBRIA UNIVERSITY

## INTRODUCTION:

Occurrence of sports related concussion (SRC) has risen. Heterogeneous signs and symptoms make it difficult to clinically diagnose and determine when it is safe for return to play (RTP). Typically, subjective pen and paper tests are used for diagnosis and RTP decisions, as no accepted gold standard or objective assessment exists (1,2).

Impaired motor task (e.g. gait) performance may inform SRC diagnosis and RTP decisions. However, assessment is limited to clinical settings where a single snapshot of tasks are captured, which may not inform real-world function. Understanding motor impairments following SRC during extended/habitual periods may provide greater insight into functional deficits.

Inertial-based wearables (e.g. accelerometers) are objective tools for acute and habitual assessment. Here we investigate utility of an inertial wearable to gather motor task data for SRC management.

#### METHODS:

We present preliminary data of male rugby players (n=18, 19.71yrs  $\pm$ 1.02) who underwent SRC screening (SCAT5) and wore a single research-grade wearable (AX6, Axivity: 100Hz,  $\pm$ 16g) on the lower back (L5) continuously for 3-days. Players also performed motor tasks within clinic (wearable on L5): timed up and go, standing balance, 2-min walk, repeated sit-to-stand transitions and 4-m gait speed using validated methods to generate spatio-temporal data (3). Testing was conducted within a 24-h period after matches.

#### RESULTS:

There was no reported discomfort due to wearable location or attachment method (direct to skin with tape). No data were lost but significant pragmatic challenges were encountered: wearable programming, deployment and management during match days. Novel data pertaining to ambulatory gait patterns ( $\alpha = 1.487$ ), variability of gait bout length ( $S2 = 1.238$ ) as well as spatio-temporal gait characteristics (e.g. step time variability = 0.0314s) provided insight into habitual behaviour and motor task performance. Additionally, wearable instrumentation provides objective quantification of motor tasks with additional insight beyond basic time and distance scores, such as mediolateral frequency components (95% percentile) during standing balance (1.96Hz).

#### CONCLUSION:

A single inertial wearable quantified novel habitual outcomes and motor tasks under observation. We present methods for objective player assessment that could be useful in providing insight beyond acute timeframes and objective measurements to better inform SRC diagnosis and RTP protocols. Future work needs to assess data sensitivity to SRC diagnosis and to address the significant challenges of using wearable approaches for SRC management such as data handling and processing at scale for pragmatic and continuous deployment.

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## SCORING TENDENCIES AT OLYMPIC GAMES IN MALE ARTISTIC GYMNASTICS SINCE THE ABOLITION OF THE “PERFECT TEN”: CONCLUSIONS FOR JUDGES’ EDUCATION TO IMPROVE PERFORMANCE DIFFERENTIATION

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#### INTRODUCTION:

In male artistic gymnastics, performance differentiation has always been a major challenge during the development of judging regulations. In view of a rising importance of difficulty and an increasing compaction of the world elite, after the Olympics 2004 the maximum score of ten points was abolished and replaced by separate difficulty (D-score) and execution scores (E-score) which are added up to the final score (F-score). Taking stock after about fifteen years, it is hypothesised that neither performance differentiation nor the importance of execution have been improved as a follow-up of the rule changes.

#### METHODS:

Reviewing the results from the last four Olympics (OG2004-OG2016), all scores from the TOP20-ranked male gymnasts in the individual qualification competitions on each apparatus were analysed. Approaching indications for performance differentiation, the percentage of the twentieth-ranked gymnast referred to the best qualification F-score (=100%) was compared between all OG. After testing for normality using the Shapiro-Wilk-test, Pearson’s  $r$  or Spearman’s  $r$  were calculated to detect correlations between F-scores and D- and E-scores respectively. One-way ANOVAs or Kruskal-Wallis-tests were calculated for all E-scores to explore changes of judging standards. Considering multiple testing, the set alpha-level (5%) was adjusted by Bonferroni-corrections for pairwise comparisons post hoc.

#### RESULTS:

Compared to OG2004 F-scores (98.85-97.20%), decreased percentages of the twentieth-ranked referred to the first-ranked gymnast were revealed for all apparatus for OG2008 (96.57-92.19%), OG2012 (97.11-90.72%) and OG2016 (96.99-92.19%). For all apparatus correlations between F- and D-scores were revealed for OG2008, OG2012 and (except for floor exercise, vault and horizontal bar) OG2016 ( $r > .70$ ,  $p < .01$ ). Between F- and E-scores, significant correlations were only obtained for OG2016 (still rings,  $r > .70$ ,  $p < .01$ ). Furthermore, decreased E-scores between OG2004 and OG2016 were revealed for all apparatus ( $p < .01$ ).

#### CONCLUSION:

Increased percentual F-score differences between the first and the twentieth-ranked gymnast for all apparatus indicate improved performance differentiation following the rule changes. Thus, rejecting our first hypothesis, however, further research needs to clarify whether this objectively improved differentiation actually initiates improved transparency with respect to the assessment of gymnastics performances. Correlations between F- and D-scores which were not obtained for F- and E-scores are in line with our second hypothesis suggesting an unimproved relevance of execution in follow-up to the rule changes. Facing generally decreased E-scores, the developers of male artistic gymnastics code of points are suggested to reconsider the appreciation of virtuosity for future rule adaptations.

Consequently, future judges’ education may need to raise judges’ courage for using a larger corridor to differentiate execution quality and to allow perfection again.

## THE EFFECT OF PLAYING HOME OR AWAY ON GAME DEMANDS IN NCAA DIVISION-I MALE BASKETBALL PLAYERS

OLTHOF, S.B.H.1, STONEMAN, B.2, BODARY, P.2, WONG, A.3, ZERNICKE, R.1,4

UNIVERSITY OF MICHIGAN

#### INTRODUCTION:

Research has demonstrated the effect of playing at home or away on game demands in several team sports with varying results. Game demands were reported higher in home games in elite soccer (Lago-Peñas & Lago-Ballesteros, 2011), but were also reported higher in away

games in elite soccer (Redwood-Brown et al., 2018) and professional basketball (Fox et al., in press). In the National Collegiate Athletic Association Division-I (NCAA D-I) basketball competition, multiple games per week are played with limited days in between to recover. Monitoring the physical loads in these games provides valuable information how to schedule load and recovery before and after these games. However, information on the game demands in NCAA D-I basketball players has not been reported. Therefore, the aim is to investigate the effect of playing home vs. away on game demands in NCAA D-I male basketball players.

#### METHODS:

Twenty conference games of one collegiate team were included in the study, and the games were equally balanced between home and away during the 2018-2019 season. Games were played according to the NCAA D-I men's basketball regulations. Game demands of five starting players (n = 96 records; age = 20.9 ± 1.09) were recorded with Catapult S5 (Melbourne, Australia). External loads were quantified as player load and the number of total and high accelerations, decelerations, change of directions, and jumps. Differences in game demands were statistically evaluated for home and away games (MANOVA).

#### RESULTS:

Away games accounted for higher demands than home games. Player load (991.0 ± 107.52 vs 919.5 ± 106.71 AU, p<.05) and the number of total jumps (216.8 ± 54.60 vs. 178.1 ± 38.22, p<.05) and total decelerations (201.6 ± 44.48 vs. 174.6 ± 37.90, p<.05) were higher on the road than at home. The variables of high intensity did not differ from playing home or away. Playing minutes for the starting players were on average 33.2 ± 4.27 min in home games and 32.6 ± 4.34 min in away games.

#### CONCLUSION:

Findings indicated a significant influence of playing in a team's home stadium. It resulted in lower game demand than in away games. Although the starting players had similar playing minutes for both home and away, the game demands were higher for the away games. Comparable results were found in Australian basketball (Fox et al., in press). Findings may be related to the players having no school obligations on game day and a smaller traveling team during away games. Quantifying game loads is important to understand the effect of game location on basketball players and may lead to further optimizing of practice schedules, while taking load and recovery into account during the competitive season.

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## MUSCLE TYPOLOGY AS A NOVEL RISK FACTOR FOR HAMSTRING STRAIN INJURIES IN PROFESSIONAL FOOTBALL

LIEVENS, E., VAN-VOSSEL, K., VAN-DE-CASTEELE, F., WEZENBEEK, E., WITVROUW, E., DERAIVE, W.

GHENT UNIVERSITY

#### INTRODUCTION:

Hamstring strain injury (HSI) is a very common and frequently recurring injury in most team sports, and is responsible for a high number of missed matches and economical loss in professional football (soccer) (1). Despite considerable scientific and medical attention to the problem, risk factors remain poorly understood and incidence rates do not decline. HSI are more prevalent in the fatigued phases of a match (1), but it is unknown whether this can be linked to player characteristics. It can be hypothesized that players with a dominant fast-twitch muscle fibre type composition are more prone to fatigue. Therefore, the objective of this study was to identify whether the muscle typology is a novel risk factor for sustaining a HSI.

#### METHODS:

A prospective cohort study was conducted over 3 consecutive seasons in 61 Belgian and 34 United Kingdom professional football players. The muscle typology was non-invasively estimated using proton magnetic resonance spectroscopy, and was characterized as fast (z-score >0.5), intermediate or slow (z-score < -0.5) muscle typology based on the carnosine concentration in the soleus muscle (2). During the 1-3 years follow-up period, all sustained injuries were monitored. A Cox regression model was used to identify risk factors for HSI. Moreover, game time-motion data (STATS SportVU) were analysed in order to measure football related fatigue using a repeated measures MANOVA.

#### RESULTS:

Professional football players spanned the entire range of the 3 main typologies, with slight predominance of slow typology (47.6 %) and intermediate typology (32.8%), compared to fast typology (19.7%). Belgian players with a fast typology displayed a 6.7-fold higher risk than slow typology players to sustain a new HSI (14 HSI, P=0.024), and this was independently confirmed in the United Kingdom cohort (5.0-fold risk, 13 HSI; P=0.023). Together, the combined cohort (27 HSI) showed a hazard ratio of 1.83 (1.26-2.66; P=0.002), i.e. when the z-score increases with 1 unit, an athlete has 83% more chance to get a HSI. In Belgium, fast typology players exhibited a significantly larger decline in high speed running in the second vs first half of their games when compared to slow typology players (respectively, -11.8% vs -4.9%; P=0.039), indicating higher fatigability.

#### CONCLUSION:

The discovery of muscle typology as a novel and strong risk factor to sustain HSI, has implications for all sprint and intermittent sports suffering from high HSI incidence. Muscle typology is mostly genetically determined, so could be considered as a non-modifiable risk factor. However, individualisation of training and match regimes may reduce fatigue accumulation of fast typology players and could be considered in future strategies to reduce HSI incidence

#### REFERENCES:

- 1 Ekstrand et al. (2011). *Am J Sports Med*, 39: 1226–32.  
 2 Baguet et al. (2011). *PLoS ONE*, 6, e21956

## EVALUATION OF APPROPRIATE METHODS TO ASSESS BIOLOGICAL MATURITY STATUS IN ELITE YOUTH SOCCER

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1 UNIVERSITY OF TÜBINGEN, GERMANY; 2 UNIVERSITY HOSPITAL GOETHE UNIVERSITY FRANKFURT, GERMANY; 3 DFB ACADEMY, GERMANY; 4 EHSM MAGGLINGEN, SWITZERLAND

#### INTRODUCTION

The influence of biological maturity on talent identification and development within elite youth soccer is critically debated within current research. Especially during early to middle adolescence maturity-related performance differences within the same age group may cause greater chances of being selected and promoted for early maturing players (Bradley et al., 2019). Therefore, it is essential for coaches to

consider athletes' biological maturity when making decisions in terms of talent selection. While the gold standard for assessing biological maturity in young adolescents are expensive and time-consuming imaging techniques in medicine (i.e., x-ray, MRI), there exist also more pragmatic procedures. Thus, the aim of the present study was to evaluate these commonly used methods to assess biological maturity within a highly selected sample of youth soccer players.

#### METHODS

A total of  $N = 63$  elite soccer players (U12:  $n = 32$ , U14:  $n = 31$ ) attending either a competence center or youth academy within the German Soccer Association's talent promotion program completed a test battery assessing maturity status outcomes. Utilizing MRI diagnostics of the left hand-wrist, players' skeletal age (Greulich-Pyle method, SA[MRI]) was determined by three qualified radiologists (interrater-reliability ICC = .91) and served as the gold standard based on which further commonly used methods were evaluated (Lloyd et al., 2014). These included skeletal age measured by a mobile ultrasound device (SA[US]), the age of peak height velocity (APHV, Mirwald et al., 2002), and the percentage of adult height (PAH, Khamis & Roche, 1997). Correlation analyses for each age group were performed to analyze the methods' reliability and validity.

#### RESULTS

Satisfying retest-reliabilities for SA[US], APHV, and PAH were found ( $r > .97$ ). The comparison of SA[MRI] and further maturity status variables for the total sample revealed correlation coefficients from  $|r| = .80$  for SA[MRI] and SA[US] to  $|r| = .84$  for SA[MRI] and PAH (each  $p < .001$ ). When looking at the age groups separately, correlations within U14 were slightly higher ( $.67 \leq |r| \leq .73$ ; each  $p < .001$ ) than those for U12 ( $.55 \leq |r| \leq .70$ ; each  $p < .01$ ).

#### DISCUSSION

The results indicate the use of economical and time-efficient methods for assessing maturity status within elite youth soccer in order to include information about athletes' biological maturity within the talent promotion process. The correlations within U14 players highlight the measures' usefulness especially for this age group. However, further comparative analyses seem necessary to investigate individual level differences which could be observed for the outcomes of the utilized procedures.

#### REFERENCES

- Bradley et al. (2019). *Ann Hum Biol*, 1-9.  
 Lloyd et al. (2014). *J Strength Cond Res*, 28(5), 1454-1464.  
 Mirwald et al. (2002). *Med Sci Spo Ex*, 34(4), 689-694.  
 Khamis & Roche (1994). *Ped*, 94(4), 504-507.

## Invited symposia

### IS-SH04 TOO YOUNG FOR SPORT?

#### THE SPORTING CHILD – A HISTORICAL STUDY OF THE SOCIAL CONSTRUCTION OF CHILDREN'S' BODIES THROUGH SPORT

SOLENES, O.

*MOLDE UNIVERSITY COLLEGE*

There seems to be an inherent tension in children's sport. On the one hand, there is a wish to do what is considered to be "in the best interest" of the child (i.e. better health, personal development, etc.). On the other hand, the "sporting logic", with competition and ranking based on performance, define other arguments for children's sport activities. Through history arguments for why children should, or should not, do sport have varied, and the knowledge, from which one has determined what might be "in the best interest of the child", has shifted. These shifts are connected to the social construction of children, their bodies, childhood and childrens sport participation. Medical knowledge about the body has played an important part in defining it, its strengths and possibilities, as well as its limitations. During the 20th century the understanding of which age is too young for a child to do sport has changed, and in general one can talk about a childification process in sport where the sporting child has become younger (Lindroth 1991; Goksøy 2008; Solenes 2009; Carlsson & Fransson 2006:2). Commercialization of sport has posed new challenges as children have become commodities as various actors (with commercial interests in sport) start to identify, select and develop sport talents at a younger age. The aim of this presentation is to analyze shifts and tensions. Historical sources, such as archive material, scientific publications and textbooks, as well as newspapers and interviews are used.

#### TOO YOUNG TO RIDE?

THORELL, G., HEDENBORG, S., ROSÉN, A.

*THE SWEDISH NATIONAL EQUESTRIAN CENTRE*

One hundred years ago, equestrian sports were foremost an activity for military men, or men and women of the upper classes. After World War II, the number of riding schools increased (Borgen 1979; Hedenborg 2013). From the mid-1980s until the beginning of the 21st century, the number of riding associations in Sweden has increased from around 100 to over 1000. About half of these are riding schools with activities for children and adolescents, as well as for adults (Thorell et al, 2016). Over time, equestrian sport has followed a general pattern in sport – childification (Lindroth 1991; Goksøy 2008; Solenes 2009; Carlsson & Fransson 2006:2). Riding instructors' knowledge of how teaching methods could be adapted to children has been an important priority for the riding association. Despite these changes, research shows that the learning environment has continued to be strongly inspired by a traditional military discourse centering on commanding (Thorell et al. 2016). In this presentation, pre-school childrens present activities in the stable are presented and problematized. About 50% of the Swedish riding schools offer activities for pre-school children - possibly for economic reasons as focus groups interviews with riding instructors demonstrate that many of them say that pre-school children are too young to ride.

**TOO YOUNG FOR SPORT? INSIGHTS EMERGING FROM CANADIAN PRESCHOOLERS' EARLY SPORT EXPERIENCES**

FRASER-THOMAS, J., HARLOW, M.

YORK UNIVERSITY

The social context of youth sport is constantly evolving. Over the past two decades, changes have been most evident among the youngest demographic – children under 6 years of age - with increased availability of and uptake in organized sport programming. Despite precautions by professional medical associations (e.g., American Academy of Pediatrics, 2019), and limited guidance by sport organizations and policies (e.g., LTD Model; Canadian Sport for Life, 2019), key societal shifts in lifestyle, sense of community, and ideals of “good” parenting, coupled with changes in sport system approaches to talent and sport development, appear to be driving this phenomenon (Ericsson et al., 1993; Pynn et al., 2018). Guided by Bronfenbrenner’s Ecological Systems Theory (EST; 1994), this presentation examines preschooler sport in the Canadian context with a focus on: (a) key social factors influencing shifts towards earlier sport participation, (b) aims and expectations of preschooler sport programs, (c) programmers’ and participants’ experiences within programs, and (d) practical and research directions moving forward. Data collected in Canada over the past five years indicates extensive aims and expectations of preschooler programs. For example, examination of over 100 websites indicate programs’ substantive claims of physical, psychological, social, and cognitive developmental benefits for preschool-aged children (Calero et al., 2018). Similarly, in other recent work, parents identified physical literacy, energy management, social competence, life skills, school readiness, and learning to win and lose as key motivations for enrolling preschool-aged children in sport (Harlow, 2019). Despite these claims and expectations, program observations and interviews with parents, coaches, and preschoolers suggest children’s experiences are nuanced, with only minimal evidence of aspirational aims and expectations being met. Findings speak to the importance of considering key individual differences in line with children’s age, developmental capacities, sport readiness, and concurrent attendance of other organized programs. Coaches of community-based programs also shed light on challenges of preschooler program delivery – most notably engaging children - given coaches’ own limited preparation to successfully execute their roles. Yet, coaches from private or for-profit programs appear to have more training, preparation, and support. Collectively, this work sheds light on a sport system and approach that has evolved more rapidly than the research informing and supporting it (Harlow et al., 2018). In line with Bronfenbrenner’s (1994) EST, extensive research is required both at microsystem and distal system levels to (a) best understand optimal delivery of programming by parents, coaches, and programmers to foster preschoolers’ development through sport, and (b) inform and guide frameworks and policies aimed at fostering preschoolers’ optimal development through sport.

## Live Sessions: Thursday, October 29, 2020

08:00 - 10:00

### IS-PN04 MUSCLE FIBRE TYPE SPECIFIC INSIGHTS ON MUSCLE FUNCTION AND METABOLISM

#### A CELLULAR APPROACH TO MUSCLE ANALYSES: ADVANCES LEADING TO GREATER MECHANISTIC INSIGHT

MURPHY, R.M.

LA TROBE UNIVERSITY

Skeletal muscle is a heterogeneous tissue, comprising of muscle fibres distinct in metabolic and contractile properties, broadly classified as type I (oxidative) or type II (either oxidative or glycolytic) fibres. Biochemical analyses of whole muscle collected from humans, typically from the mixed vastus lateralis muscle, involves simultaneous investigation of the muscle fibre types present in a given muscle sample. Muscle fibre type composition in a given individual can be influenced by a number of factors including age and training status. Not surprisingly, abundances of many proteins, including mitochondrial proteins, have been identified as being dependent on the muscle fibre type. Exercise training can result in differential responses of particular proteins in the broadly distinct muscle fibre types and thus, whole muscle analyses can mask fibre type specific responses and hence limit the mechanistic insight that can be obtained using these analyses. Further, the use of a calibrated western blotting system and inclusion of the whole muscle sample, allows the relative abundance of proteins to be determined quantitatively.

Mitochondrial dynamics proteins are critical for mitochondrial turnover and maintenance of mitochondrial health. Examination of whole skeletal muscle homogenates from younger (18-30 years old) and older (68-73 years old) healthy adults found no difference in mitochondrial content as measured by citrate synthase activity and the abundance of mitochondrial respiratory complex proteins, cytochrome oxidase IV (COXIV) and NADH:ubiquinone oxidoreductase subunit A9 (NDUFA9,  $p > 0.05$ ). The proteins were higher in type I compared to type II muscle fibres isolated from biopsies from both younger and older adults. Mitochondrial dynamics proteins, mitofusin-2 (Mfn2) and mitochondrial dynamics protein 49 (MiD49,  $p < 0.05$ ) were more abundant in muscle from older compared with younger adults, but optic atrophy 1 (OPA1) or dynamin related protein 1 (Drp1) were not different ( $P > 0.05$ ). When assessed in a fibre-specific manner, the higher Mfn2 was entirely due to a greater abundance in type II muscle fibres. High-Intensity Interval Training (HIT) is a potent training modality, and resulted in mitochondrial adaptations, with increases in citrate synthase activity and mitochondrial content as measured by COXIV and NDUFA9 protein ( $p < 0.05$ ), in both young and older adults. In younger adults, Mfn2 protein content increased with HIT yet in older individuals Mfn2 protein content decreased.

At the single fibre level, these findings reveal (i) a similar mitochondrial content in muscle from young and healthy older adults, with similar proportions between type I and type II muscle fibres; and (ii) an increase in the abundance of Mfn2 and MiD49 protein contents in muscle from older compared with younger adults, with Mfn2 being confined to type II fibres.

#### A TALE OF TWO FIBRE TYPES: INTRAMUSCULAR LIPID METABOLISM AND AUTOPHAGY

SHAW, C.

DEAKIN UNIVERSITY

Intramuscular lipids (IMCL) are an important substrate for active individuals during moderate intensity exercise, while IMCL accumulation in sedentary individuals is associated with deteriorations in insulin action. Technical advances over the last 20 years have enabled investigations using muscle fibre type specific analysis of IMCL content and related regulatory proteins in human muscle biopsies using both immunofluorescence microscopy and quantitative immunoblotting. These advances are particularly relevant for the analysis of IMCL metabolism, as traditional biochemical analysis on whole muscle can be confounded by differences in muscle fibre type. Furthermore, contamination from non-muscle tissue, in particularly intermuscular adipocytes, can markedly influence assessments of lipid content, composition and abundance of many regulatory proteins.

IMCL content is typically ~2-3-fold greater in type I muscle fibres compared to type II fibres. Reductions in IMCL of up to 80% occur after prolonged, moderate intensity exercise in type I muscle fibres, while changes in type II fibres are negligible. These findings are in-line with a coordinated upregulation of lipid droplet-associated proteins, lipases and enzymes of  $\beta$ -oxidation in type I fibres which enables enhanced capacity for both IMCL storage and utilisation. We have recently shown that the maximal capacity for fat oxidation is related to the proportion of type I muscle fibres. Furthermore, the high capacity for IMCL use in endurance-trained individuals occurs alongside a higher proportion of type I fibres and greater abundance of lipid regulatory proteins. However, the transcriptional and post-translational mechanisms regulating these fibre type specific differences are not well understood.

The emerging role of autophagy in mitochondrial turnover and interactions with lipid metabolism has focused attention on autophagy in skeletal muscle. In mice, muscle with a high oxidative capacity has a greater abundance of autophagy machinery and elevated markers of autophagy flux. In several human studies, we have shown that type I muscle fibres exhibit a greater abundance of the autophagosome marker LC3-II under basal conditions, while autophagy responses following an acute bout of exercise are specific to type I muscle fibres. On the other hand, our data shows that autophagy inhibition following the ingestion of a meal occurs in both type I and type II muscle fibres.

This talk will cover recent data that highlight the importance of considering muscle fibre type when investigating muscle lipid metabolism and autophagy. These considerations will remain important with the growing application of larger scale 'omic' techniques to understand muscle metabolism and its regulation in the context of exercise, nutrition and disease states.

## SKELETAL MUSCLE FIBER TYPE MODIFIES OUR RESPONSE TO ACUTE COLD EXPOSURE – AN EXPLANATION FOR THE EVOLUTIONARY SELECTION OF THE ACTN3 577X ALLELE IN HUMANS

WYCKELSMÄ, V.

KAROLINSKA INSTITUTET

The sarcomeric protein  $\alpha$ -actinin-3 (ACTN3) resides in the Z-discs of fast skeletal muscle fibres, where it cross-links the actin filaments of adjacent sarcomeres. ACTN3 interacts with a number of proteins, which broadly are involved in structural, metabolic, signalling and calcium handling pathways. Human ACTN3 deficiency is more common in places with lower annual temperature and previous studies have eluded that lacking ACTN3 is beneficial for those living in colder temperatures. Human volunteers deficient in ACTN3 (XX) and control (RR) were exposed to cold using an intermittent whole-body water immersion protocol. Subjects entered water baths (14 degrees Celsius) for 20 min followed by a 10 min rest. This intermittent whole-body water immersion procedure continued until either the rectal temperature had decreased to 35.5 degrees or a maximum of 120 min of cold-water immersion.

The average rate of rectal temperature decline in RR subjects was about two times higher than in XX subjects. The temperature in the gastrocnemius muscle, measured before and after water immersion, also showed a faster decline in RR than in XX subjects, whereas the decline in skin temperature was not significantly different between the two groups. Muscle biopsies collected at baseline revealed a larger proportion of oxidative slow-twitch fibres in XX than in RR subjects, which fits with an oxidative phenotype and better exercise endurance in XX subjects. To further understand any additional molecular mechanisms behind superior cold tolerance in XX humans, ACTN3 KO mice were housed for 4hrs in the cold (4 degrees Celsius) or thermoneutral (30 degrees Celsius) and were sacrificed thereafter. RNA sequencing showed that both cold-exposed KO and WT mice had upregulation of genes controlling oxidative mitochondrial and metabolic proteins. In conclusion, our findings indicate that an increased proportion of oxidative muscle fibres results in improved cold tolerance.

## OP-BM13 MOTOR LEARNING AND MOTOR CONTROL; BIOMECHANICS

### MOVEMENT SMOOTHNESS AS A MARKER FOR ADAPTATIONS IN MOTOR CONTROL: THE EXAMPLE OF FATIGUE

MOHR, M., LÖFFLER, S., SCHMIDT, A., PIEPER, R., FEDEROLF, P.

UNIVERSITY OF INNSBRUCK

#### INTRODUCTION:

Smoothness is a hallmark of skilled, healthy human movement, i.e. the movement trajectories appear fluent without any interruptions [1]. Despite its important role as a recovery marker for efficient motor control in neurological patients, smoothness in the athletic context has mainly been discussed qualitatively [2]. Quantifying movement smoothness of athletes, however, may provide novel insight into technique improvements, the development of fatigue, and/or the risk of injury. The purpose of this study was to test the hypothesis that the smoothness of pelvis and foot motion declines over time as athletes fatigue during a lateral shuffle test to exhaustion.

#### METHODS:

Thirteen sport science students shuffled back and forth between two target zones (3x leg length) until exhaustion. Participants shuffled according to a metronome near their maximum shuffle speed as determined from a previous shuffle exercise. 3D motion analysis (250 Hz) was used to track the motion of the pelvis (average of four iliac spine markers) and the right foot (heel marker). Position data were differentiated three times (velocity, acceleration, jerk) using a low-pass filter at 15 Hz before each derivative. Movement smoothness of the pelvis and foot in the horizontal shuffle direction were determined for each shuffle segment according to (a) a cumulative, normalized measure of jerk (log-dimensionless jerk, LDLJ) and (b) the spectral arc length of the velocity power spectrum (SPARC) [3]. Paired t-tests ( $\alpha=0.05$ ), effect sizes (ES), and percentage changes were computed to investigate changes in smoothness between the first and last five shuffle segments

#### RESULTS:

Significant reductions in pelvis movement smoothness with large effect sizes were observed during the last five (fatigued) compared to the first five (unfatigued) shuffle segments [LDLJ:  $p<0.001$ ,  $ES=1.52$ ; SPARC:  $p=0.008$ ,  $ES=0.88$ ]. For foot motion, only the LDLJ measure resolved a significant reduction in smoothness [LDLJ:  $p<0.001$ ,  $ES=1.57$ ; SPARC:  $p=0.053$ ,  $ES=0.59$ ]. The mean percentage reductions in LDLJ and SPARC were -5% and -3% for the pelvis and -2.5% and -4.3% for the foot, respectively.

#### CONCLUSION:

The smoothness of the horizontal pelvis and foot motion significantly declined over the course of a fatiguing shuffle test. This finding demonstrates the ability of smoothness measures to detect fatigue-induced deterioration of efficient motor control strategies during sport-specific movements. In parallel to upper extremity models, we speculate that as athletes fatigue, higher muscle activation is necessary to maintain the shuffle speed, leading to increased noise in motor output and less accurate and predictable movement trajectories [1]. The detection of deteriorating motor control according to measures of smoothness may provide a new approach to predict exhaustion and potentially injury risk during exercise.

#### References:

- [1] Harris & Wolpert. Nature. 1998.
- [2] Kiely et al. Sports Med Open. 2019.
- [3] Balasubramanian et al. J. Neuroeng. Rehabil. 2015.

### EFFECT OF MUSCLE CONTRACTION TYPE ON CORTICOMUSCULAR COHERENCE

GLORIES, D., SOULHOL, M., AMARANTINI, D., DUCLAY, J.

UNIVERSITÉ PAUL SABATIER

#### INTRODUCTION:

Corticomuscular coherence (CMC) between electroencephalography (EEG) and electromyography (EMG) is considered suitable when evaluating mutual interaction between cerebral and muscle oscillatory activities during contraction. It has been suggested that CMC modulation would, at least partially, depend on the contribution of spinal mechanisms (Williams et al. 2009). It is now well established in literature that muscle contraction type may induce changes in spinal excitability, with a decrease specifically observed during lengthening contractions (Duclay et al 2011). The comparison of CMC between isometric, shortening and lengthening contractions could therefore offer



the opportunity to clarify the role of spinal mechanisms in CMC. Thus, the main goal of this study was to investigate the effect of muscle contraction type on CMC between the primary motor cortex and plantar flexor muscles, with a concurrent analysis of spinal excitability to obtain a more complete picture of the neural mechanisms involved in the modulation of CMC.

#### METHODS:

Twenty-five participants performed isometric, lengthening and shortening submaximal voluntary contractions of the plantar flexor muscles on an isokinetic ergometer. Soleus (SOL) and medialis gastrocnemius (MG) EMG and 64-channel EEG were recorded. For each contraction type, the required force level corresponded to 50% of SOL EMG activity measured during maximal isometric voluntary contractions. CMC was computed in the time–frequency domain (Bigot et al. 2011) between Cz EEG and unrectified EMG SOL (CMC SOL-Cz) or MG (CMC MG-Cz) signals in the Beta-band (13–32 Hz). Spinal excitability was quantified through normalized H-reflex amplitude.

#### RESULTS:

CMC SOL-Cz was significantly reduced during lengthening compared to isometric contractions ( $p < 0.01$ ) while no significant difference was found between isometric and shortening contractions ( $p > 0.05$ ). SOL normalized H-reflex was significantly reduced during lengthening when compared with isometric and shortening contractions ( $p < 0.01$ ), but was similar between isometric and shortening contractions ( $p > 0.05$ ). No significant contraction type effect was shown for CMC MG-Cz ( $p > 0.05$ ) and for MG normalized H-reflex ( $p > 0.05$ ).

#### CONCLUSION:

The specific CMC SOL-Cz decrease during lengthening contractions highlights an effect of contraction type on CMC. Associated with the concurrent decrease in spinal excitability during lengthening contractions, this novel finding strongly underpins a relation between CMC modulation and that of spinal excitability. Furthermore, this study indicates that the specific modulation of CMC observed across contraction type differs between synergist agonist muscles. The lack of contraction type effect on both CMC and H-reflex for MG confirms the contribution of spinal regulatory mechanisms to CMC amplitude.

Bigot J et al. (2011). *Neuroimage* 55, 1504–1518.

Duclay J et al (2011). *J-Physiol* 589, 2901–2916.

Williams R & Baker S (2009). *J Neurosci* 29(20), 6616–6624.

## EXPERIMENTAL MUSCLE PAIN REDUCES ENDURANCE AND MAXIMAL STRENGTH VIA CENTRALLY MEDIATED MECHANISMS

NORBURY, R., SMITH, S.A., BURNLEY, M., MAUGER, A.R.

UNIVERSITY OF KENT

#### INTRODUCTION:

Pain has been shown to reduce maximal strength and endurance performance (Graven-Nielsen, Svensson, & Arendt-Nielsen, 1997) but it is unclear which mechanisms cause this. Specifically, it is not known if pain results in voluntary disengagement from exercise due to an intolerable sensation, or directly contributes to neuromuscular fatigue. To investigate the underpinning mechanisms, intramuscular injections of hypertonic saline can be used to cause muscle pain. Therefore, the aim of this study was to experimentally induce muscle pain during an endurance task and to assess the mechanisms of fatigue.

#### METHODS:

Ten (2 Female) (Mean  $\pm$  SD Age:  $26 \pm 4$  yrs, height:  $1.75 \pm 0.09$  m, mass:  $72.7 \pm 10.8$  kg) participants completed four visits separated by 2–7 days. After an initial familiarisation (visits 1 and 2), participants completed a single limb isometric time to task failure (TTF) of the knee extensors at 20% of maximum voluntary force. Either 1 mL of hypertonic saline (5.85%) to induce pain (HYP) or isotonic saline to act as the non-painful control (CON) was injected into the vastus lateralis immediately prior to exercise. Measures of maximum voluntary force (MVf), voluntary activation (VA), electrically evoked quadriceps twitch doublet force (Q<sub>tw</sub>), motor evoked potential amplitude (MEPAMP) and silent period duration (SP) evoked with transcranial magnetic stimulation (TMS) were recorded intermittently throughout the TTF to track neuromuscular fatigue. Pain intensity was continuously measured on a 0–100 visual analogue scale.

#### RESULTS:

Mean pain was greater in HYP ( $57 \pm 11$ ) compared to CON ( $44 \pm 14$ ) ( $P = 0.004$ ,  $d = 1.22$ ) which decreased TTF by 17.4% from  $5.14 \pm 0.4$  min to  $4.24 \pm 0.9$  min ( $P = 0.006$ ,  $d = 1.13$ ). MVf was 10.9% lower in HYP than in CON at minute 1 of exercise ( $P = 0.041$ ,  $d = 0.97$ ) and a greater  $\Delta$ MVf/ $\Delta$ Time in HYP compared to CON ( $P = .002$ ,  $d = 0.89$ ). VA was also 4.8% lower at minute 1 in HYP compared to CON (Wilcoxon  $P = 0.018$ ,  $r = -0.82$ ), with increased pain inversely correlated with the reduction in VA ( $r = -0.824$ ,  $P = 0.003$ ). The SP was also longer in HYP compared to CON at 100 s of TTF ( $P = 0.045$ ,  $d = 0.92$ ) but not at 10 s or task failure. No difference was seen in MEPAMP ( $P = 0.754$ ) and Q<sub>tw</sub> ( $P = 0.822$ ) between conditions.

#### CONCLUSION:

Increasing pain during endurance exercise reduces TTF and decreases maximum muscle strength. These decrements in function are likely related to the exacerbation of central fatigue as seen by greater decreases in VA, and a lengthening of the SP in HYP compared to CON, whereas no differences were observed in peripheral fatigue. An increased level of inhibitory afferent feedback from group III/IV nociceptors of the painful muscle are likely mediating these changes in neuromuscular fatigue. In conclusion, this study provides novel evidence that muscle pain/nociception directly causes neuromuscular fatigue and imposes a limitation to endurance performance.

References: Graven-Nielsen et al., (1997). *Electroen Clin Neuro*, 105(2), 156–164.

## IS-AP08 INDIVIDUALIZED TRAINING PRESCRIPTION AND INJURY PREVENTION IN RACKET SPORTS

### INDIVIDUALIZED TRAINING IN RACKET SPORTS – THEORETICAL FOUNDATION AND PRACTICAL EXAMPLES

FERRAUTI, A.

RUHR UNIVERSITY BOCHUM,

This presentation will focus on (1.) constructing a long-term individual physical training concept, (2.) an approach for the mid-term fine tuning of technical, physical and psychological skills, and (3.) a statistical approach for the short-term daily monitoring of fatigue and recovery and the respective training prescription in professional players.

- 1) The long-term perspective: Cross-sectional and multiple regression analysis of data from more than 3.000 national ranked junior tennis players are used to define target values in physical components related to biological age and playing style. An evidence based decision tree for individual training advices is presented.
- 2) The mid-term perspective: Data from tennis Davis-Cup players are reflecting individual differences in specific on-court skills (e.g. metabolic power of strokes, ground contact times) and in their psycho-physiological response to real Davis-Cup matches (e. g. adrenaline release) which underlines the individual needs for coaches' support.
- 3) The short-term perspective: A daily monitoring system consisting of physiological (e. g. CK, heart rate measures), physical (e. g. jump performance) and psychometric measures (e. g. DOMS) with data from elite badminton and tennis players will be presented. Individualized reference ranges (following a Bayesian approach) and a multifactorial decision tree is applied to distinguish between recovered and non-recovered states and to improve accuracy of training advices.

## SCIENCE AND INDIVIDUAL APPLICATION OF HIGH-INTENSITY INTERVAL TRAINING IN RACKET SPORTS

FERNANDEZ-FERNANDEZ, J.

*FACULTY OF PHYSICAL ACTIVITY AND SPORTS SCIENCES. UNIVERSIDAD DE LEÓN*

This presentation will focus on different high-intensity interval training (HIIT) methods, their manipulations, and the use of monitoring tools to check their effectiveness. Moreover, practical examples of how to introduce different exercises into the daily practice will be provided. The presentation will have three different parts:

- 1) Acute effects of different training interventions in the physical profile of adult and young racket sport athletes. Questions raising from this part include: the effects of physical performance on sport-specific performance or the timing of the training interventions (i.e., pre-season, in-season).
- 2) Maintaining technical skills is a determinant factor in these sports and training time is at a premium. The question here is if on-court training sessions integrating both technical/tactical and physical components is better than a run-based approach.
- 3) Acute effects of intensive training periods, including the use of high-intensity shock microcycles and/or periods of overload, on performance in racket-sport athletes. Despite the fact that in different racket sports, weekly training schedules include variable and, most of the times, uncontrolled training loads, the effects of these periods are unknown. Moreover, since these periods are considered to be potential precursors to injury or overreaching states in other sports, it seems important to analyse the responses to these intensive training periods especially in youth athletes.

## MONITORING TOOLS FOR INJURY PREVENTION IN RACKET SPORTS – CAN WE SIMPLY COPY WHAT OTHER SPORTS DO?

GESCHEIT, D.

*TENNIS AUSTRALIA*

This presentation will focus on the efficacy of monitoring tools utilized in tennis to identify injury risk. Historically, the etiology of tennis injuries remained largely unexplored. Despite the lack of evidence, the use of monitoring tools to determine injury risk still remains common practice. These tools are typically 'borrowed' from other sports which have greater evidence for their efficacy. Therefore, this presentation will explore commonly applied univariate and multivariate monitoring tools in tennis to determine their association to injury risk.

- 1) The univariate analysis - The ability of load monitoring to predict subsequent tennis injuries will be discussed. The selection of load metrics and timeframes as well as the statistical analysis have been critiqued. Therefore, a host of load monitoring calculations, as well as timeframes will be discussed to determine 1) if injuries can be predicted in tennis and 2) if so, which load model and timeframe performs best at predicting such injuries.
- 2) The multivariate analysis – The multifactorial nature of injury emphasizes that a multivariate approach to assessing the interaction between risk factors and injury is fundamental. This section of the presentation will explore commonly utilized injury risk monitoring tools (e.g. musculoskeletal screening, fitness testing, internal and external loads). The outcomes will highlight which combination of monitoring tools are best to determine injury risk in tennis.

## IS-SH05 THE PHYSICAL EDUCATION SETTING: A CONTEXT TO INQUIRY, ANALYSE AND REFLECT ON

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### WHAT PE TEACHERS THINK ABOUT THEIR REAL PRACTICE? A QUALITATIVE INQUIRY

COTERON, J.

*UNIVERSIDAD POLITÉCNICA DE MADRID*

Students' perceptions of the Physical Education (PE) setting seem to have an important influence on future behaviours. It explains the increasing popularity of research in this context over the last few years. There is a well-based evidence showing that the climate fostered by teachers' performance might affect countless students' outcomes. However, literature is scarce in studies addressing which factors can determine these outcomes.

Previous research has pointed out that teachers' behaviours might be affected by their perception of both constraints at work and students' motivation. More recently, it has been hypothesized that different kind of pressures (such time constraints during lessons, students' performance or management duties) could negatively influence teachers' motivation which, in turn, could lead to ill-health. Quantitative methods have been mainly used in the research noted above.

In this lecture, a qualitative research based on semi-structured interviews to experienced PE teachers will be exposed. The study to be presented aims a) to detect best practices among PE teachers which could enhance an adaptive setting climate as well as b) to identify possible barriers and facilitators to implementing these practices. Findings will offer considerable insight into which factors are perceived by teachers as potential constraints to their best practices.

**TEACHERS AND STUDENTS' PERCEPTIONS IN THE PHYSICAL EDUCATION CLASS. TO WHAT EXTENT ARE THEY RELATED?**

FRANCO, E.

UNIVERSIDAD PONTIFICIA DE COMILLAS

Self-Determination Theory distinguishes three basic psychological needs (BPN) that, applied to the educational field, appear as required conditions for the students to get optimally involved into their learning process. Numerous previous findings suggest that the perception of an autonomy-supportive context can contribute to the satisfaction of these three needs (competence, autonomy and relatedness) which, in turn, can determine positive behaviour in the Physical Education (PE) context.

A recent research line has focused on the analysis of teachers' antecedents which could explain their motivating style. Previous studies have pointed out that BPN satisfaction among teachers might lead to an autonomy-supportive motivating style. On the other hand, previous research has suggested that BPN thwarting should also be considered as a possible antecedent of teachers' behaviours as it reflects feeling that BPN are being obstructed and not simply unfulfilled.

In this lecture, a large study carried out with teachers and students from five different countries is presented. The study aims to test a multilevel mediation model examining the relationship between teachers' BPN satisfaction and thwarting and students' BPN satisfaction in order to gain some insight into teachers' antecedents influencing students' motivation.

The lecture could be of interest to abroad audience including PE teachers, sport psychologists and researchers.

**KEY FINDINGS AND FUTURE DIRECTIONS IN PHYSICAL EDUCATION RESEARCH**

SPRAY, C.M.

LOUGHBOROUGH UNIVERSITY

The antecedents and outcomes of PE teachers' motivating styles has received renewed interest lately. Underpinning this line of inquiry is a belief that optimal motivation and outcomes in young people will be partly and meaningfully explained by teachers' own motivation and perceptions. Consequently, much of the research to date has been grounded in Self-Determination Theory (SDT). Both environmental and intrapersonal antecedents have been associated with needs and motivational types, which have served as mediators of teacher and student outcomes. A variety of approaches has been adopted by researchers. Lecture A identified the value of adopting a qualitative analysis, whereas in Lecture B, the value of multi-level modelling was demonstrated. Thus, empirical efforts in this research endeavour are diverse. Existing work has been informed by SDT and has furthered our understanding of factors that influence the creation of need supportive environments. However, there is a need to adopt alternative and complementary perspectives that offer theoretically grounded recommendations for practitioners. One of these to be discussed will be teachers' implicit theories of athletic ability and their link with their perceptions of the malleability of students' athletic ability. Pedagogical behaviours linked with these beliefs will be examined.

**OP-PN13 IMMOBILISATION; AGEING****CIRCULATING GDF-15 AS AN INDEPENDENT PREDICTOR OF MECHANICAL SIT-TO-STAND POWER IN HEALTHY MEN AND WOMEN AGED 20-93 YEARS**

ALCAZAR, J.1,2, FRANDSEN, U.3, FLINDT, D.M.3, KAMPER, R.S.2, HADDOCK, B.4, AAGAARD, P.3, SUETTA, C.2,5,6

UNIVERSIDAD DE CASTILLA-LA MANCHA

**INTRODUCTION:**

Mechanical power has been strongly associated with functional performance, disability and mortality at older age (1). Growth differentiation factor-15 (GDF-15) is a stress-induced cytokine that is associated with inflammation, cancer, cardiovascular disease and obesity (2). Our main goals were to assess (i) the relationship between age and circulating GDF-15 levels and (ii) the relationship between GDF-15 and sit-to-stand muscle power in a healthy population.

**METHODS:**

A total of 1151 participants (aged 20-93 years; 55% women) from the Copenhagen Sarcopenia Study were included. Relative (i.e. normalized to body mass) lower limb mechanical power was assessed by the sit-to-stand power test (2). Total fat mass was obtained by DXA scanning (iDXA, GE Lunar) and normalized to height<sup>2</sup>. TNF- $\alpha$  and hs-CRP as biomarkers of inflammation, and GDF-15 concentrations were analyzed in plasma samples. Segmented and multiple linear regression analyses were used in SPSS (SPSS Inc., EEUU).

**RESULTS:**

Circulating GDF-15 increased linearly with age albeit at different rates in men between 20 and 70 years (3.3 pg-mL<sup>-1</sup>-year<sup>-1</sup>) and above 70 years (19.3 pg-mL<sup>-1</sup>-year<sup>-1</sup>), and in women between 20 and 65 years (1.1 pg-mL<sup>-1</sup>-year<sup>-1</sup>) and above 65 years (11.5 pg-mL<sup>-1</sup>-year<sup>-1</sup>) (all  $p < 0.001$ ). In addition, GDF-15 was correlated with sit-to-stand power in both men ( $r = -0.42$ ) and women ( $r = -0.40$ ) (both  $p < 0.001$ ). Notably, the negative relationship between GDF-15 and sit-to-stand power remained present in both sexes after adjusting for age, fat mass and inflammation factors (both  $r = -0.10$ ;  $p < 0.01$ ).

**CONCLUSION:**

Age-related increases in circulating GDF-15 levels are accelerated after the age of 65 years in women and 70 years in men. Importantly, GDF-15 was negatively associated with sit-to-stand mechanical power in both women and men independently of age, obesity and inflammation status.

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**SLEEPING TOWARDS MEDALS? THE DIFFERENCE IN QUALITATIVE SLEEP BETWEEN ELITE AND NON-ELITE GYMNASTS**

DUMORTIER, J., MARIMAN, A., BOONE, J., DELESIE, L., TOBBACK, E., VOGELAERS, D., BOURGOIS, J.G.

UNIVERSITY OF GHENT

**INTRODUCTION:**

Performance of athletes depends on the optimal symbiosis of training and recovery. Quantity and quality of sleep are essential components to facilitate the recovery process. The goal of this study is to identify differences in objective sleep characteristics between elite and non-elite female artistic gymnasts. We hypothesize that elite gymnasts will show better sleep quality than non-elite gymnasts because of the higher physical loads.

**METHODS:**

Twelve elite (international competition level) and twelve age-matched non-elite female gymnasts (regional competition level) ( $15.1 \pm 1.5$  vs.  $15.4 \pm 1.6$  years old;  $31 \pm 2$  vs.  $10 \pm 2$  hours of training per week;  $VO_{2peak}$ :  $53.2 \pm 5.1$  vs.  $42.1 \pm 3.5$  ml·min<sup>-1</sup>·kg<sup>-1</sup>) underwent a nocturnal polysomnography (PSG) after a regular training day. For the PSG measurements, the gymnasts were equipped with electroencephalography, electrooculography, electrocardiography, electromyography (chin, right and left leg), posture detector, pulse oximeter (assessing oxygen saturation: SAO<sub>2</sub>), breathing detectors (on thorax and abdomen) and a manometer (measurement of oronasal pressure). Total sleep time (TST) and sleep efficiency (SE, proportion of time effectively asleep to time in bed) as well as proportion (relative to TST) of non-rapid eye movement sleep phase 1 (NREM1) and 2 (NREM2), slow wave sleep (SWS) and REM sleep during a night were compared between the elite and the non-elite gymnasts using Independent Samples T-Tests. Data are expressed as mean  $\pm$  SD.

**RESULTS:**

Both groups showed an equal amount of TST (elite:  $437 \pm 27$  min vs. non-elite:  $437 \pm 21$  min,  $P = 1.000$ ) and SE (elite:  $89.5 \pm 4.1$  % vs. non-elite:  $90.1 \pm 4.3$  %,  $P = 0.768$ ). Of the qualitative sleep measurements, no inter-group differences were found for NREM1 and NREM2 (elite:  $5.1 \pm 3.5$  % vs. non-elite:  $3.9 \pm 1.8$  %,  $P = 0.440$ ; elite:  $38.7 \pm 10.2$  % vs. non-elite:  $47.8 \pm 4.4$  %,  $P = 0.056$ ). The proportion of SWS was highest in the elite gymnasts ( $36.9 \pm 11.4$  % vs.  $25.1 \pm 5.2$  %,  $P = 0.030$ ) while REM sleep was elevated in the non-elite gymnasts ( $23.3 \pm 4.4$  % vs.  $19.3 \pm 3.9$  %,  $P = 0.031$ ).

**CONCLUSION:**

Although SE did not differ between elite and non-elite gymnasts, the higher SWS in elites indicates an improved sleep quality. SWS is an important phase within the sleep cycle with regards to physical recovery since growth hormone secretion peaks during this phase. Therefore, athletes with substantially low SWS, may be at risk for inadequate physical recovery and thus lower performance levels.

**EARLY BIOMARKERS OF MUSCLE ATROPHY AND OF NEUROMUSCULAR ALTERATIONS DURING 10-DAY BED REST**

MONTI, E., FRANCHI, M.V., SARTO, F., REGGIANI, C., TONIOLO, L., ZAMPIERI, S., SIMUNIC, B., PISOT, R., NARICI, M.V.

UNIVERSITÀ DI PADOVA

**INTRODUCTION:**

Disuse atrophy may not only arise from a reduction in mechanical loading but also from muscle denervation and neuromuscular junction damage, triggered by inactivity [1,2,3]. The identification of biomarkers of muscle atrophy and of neuromuscular degeneration is therefore needed for an early detection of the neuromuscular alterations induced by inactivity. The aim of this study was to investigate the onset of muscle atrophy and of neuromuscular alterations during a short-term inactivity period.

**METHODS:**

Ten healthy males (aged  $23 \pm 5$  years, body mass  $77.5 \pm 10$  kg, height  $181.2 \pm 3.9$  cm) participated to a 10-day bed rest (BR) study, after Ethical approval and informed consent. Blood samples were collected for the assessment of NMJ damage from serum levels of c-terminal agrin fragment (CAF). Muscle fibre denervation was determined from the expression of neural cell adhesion molecule (N-CAM) in myofibres obtained from vastus lateralis (VL) muscle biopsies at baseline and 10 days of BR. Myofibre morphological and functional changes were assessed from mean single skinned fibre cross-sectional area (CSA) and mechanical testing, respectively. Whole quadriceps (QF) muscle morphological changes were assessed from measurements of muscle volume and QF CSA, by MRI, and architecture (pennation angle), by ultrasonography. QF functional changes were assessed from measurements of maximum voluntary contraction (MVC) force (F) by isometric dynamometry. Significance of differences was tested with paired Student's t-test, level of significance was set at  $p < 0.05$ .

**RESULTS:**

Atrophy of whole muscle and of myofibres were detected after 10 days of BR, represented by (i) a 6.6% decrement in QF volume ( $P < 0.01$ ) (ii) a 13.7% reduction in mean single fibre CSA ( $P < 0.01$ ); and (iii) a 7.3% decrease in VL pennation angle ( $P < 0.0001$ ). These morphological changes were accompanied by a 14.3% drop in maximum isometric MVC ( $P < 0.001$ ), an 11.5% decrease in QF F/CSA ( $P < 0.001$ ) and a slight decrease by 3.2% in single fibres force (n.s).

Notably, a 16% increase ( $p < 0.05$ ) in CAF levels, together with an 18-fold increase in N-CAM positive myofibres were found on BR day 10.

**CONCLUSION:**

These findings show a very early onset (within 10 days) of whole muscle and fibre atrophy accompanied by NMJ damage and myofibre denervation in response to chronic inactivity. We suggest that countermeasures against neuromuscular maladaptation to chronic inactivity ought to be implemented as early as possible.

**References:**

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- [2] Arentson-Lantz EJ et al., J Appl Physiol (1985). 2016 Apr 15;120(8):965-75.
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**DAILY BLOOD FLOW RESTRICTION DOES NOT ATTENUATE MUSCLE MASS AND STRENGTH LOSS DURING 2 WEEKS OF BED REST**

FUCHS, C.J., HERMANS, W.J.H., NYAKAYIRU, J., WEIJZEN, M.E.G., SMEETS, J.S.J., SENDEN, J.M., VERDIJK, L.B., VAN LOON, L.J.C.

MAASTRICHT UNIVERSITY MEDICAL CENTRE+

**INTRODUCTION:**

Bed rest, often necessary for recovery from illness or injury, leads to the loss of muscle mass and strength. It has been suggested that blood flow restriction stimulates muscle protein synthesis and, therefore, may be used to attenuate the loss of muscle mass and strength during

bed rest. This study assessed the impact of blood flow restriction on the loss of muscle mass and strength, as well as muscle protein synthesis rates during 2 weeks of bed rest.

#### METHODS:

Twelve healthy, male adults (age:  $24 \pm 3$  y, BMI:  $23.7 \pm 3.1$  kg/m<sup>2</sup>) were subjected to fourteen days of complete bed rest with blood flow restriction performed three times daily in three 5-min cycles (200 mmHg) in a single leg. Participants consumed deuterium oxide for 1 day prior to and throughout the 2 weeks of bed rest. Before and immediately after bed rest, lean body mass (DEXA scan), thigh muscle volume (MRI scan) and cross-sectional area (CSA; CT scan) were assessed in both the blood flow restricted (BFR) and control (CON) leg. Muscle strength was assessed for both legs before and after the bed rest period (one-repetition maximum; 1RM). Muscle biopsies were collected from both legs before and immediately after bed rest to assess deuterium enrichments. Blood and saliva samples were collected throughout the bed rest period. Paired samples t-tests were used to determine differences in muscle protein synthesis rates between treatments (BFR versus CON) and differences in total lean body mass before and after the 2-week bed rest period. A two-factor (time\*treatment) repeated-measures ANOVA was performed for the analysis of leg strength, thigh muscle volume, and thigh muscle CSA. Data represent means $\pm$ SD.

#### RESULTS:

Bed rest resulted in  $1.8 \pm 1.0$  kg lean body mass loss ( $P < 0.001$ ) and a decline in both thigh muscle volume (from  $7.1 \pm 1.1$  to  $6.7 \pm 1.0$  L (CON) and from  $7.0 \pm 1.1$  to  $6.7 \pm 1.0$  L (BFR); time effect:  $P < 0.001$ ) and thigh muscle CSA (from  $156 \pm 27$  to  $146 \pm 24$  cm<sup>2</sup> (CON) and from  $155 \pm 27$  to  $146 \pm 25$  cm<sup>2</sup> (BFR); time effect:  $P < 0.001$ ), with no differences between treatments (time\*treatment effect:  $P > 0.05$ ). In addition, 1RM leg extension strength decreased from  $60.2 \pm 10.6$  to  $54.8 \pm 10.9$  kg in CON and from  $59.2 \pm 12.1$  to  $52.9 \pm 12.0$  kg in BFR (time effect:  $P = 0.014$ ), with no differences between treatments (time\*treatment effect:  $P = 0.594$ ). Muscle protein synthesis rates during bed rest did not differ between the BFR and CON leg ( $1.11 \pm 0.12$  vs  $1.08 \pm 0.13$  % d<sup>-1</sup>, respectively;  $P = 0.302$ ).

#### CONCLUSION:

Two weeks of bed rest substantially reduces skeletal muscle mass and strength. Blood flow restriction during bed rest does not attenuate the loss of muscle mass or strength, and does not increase daily muscle protein synthesis rates.

## OP-MH16 EXERCISE AND HEALTH

### CAN PRINCIPAL COMPONENT ANALYSIS HELP IDENTIFY THE BIOMECHANICAL GAIT MARKER MAINLY AFFECTED IN PATIENTS SUFFERING FROM INTERMITTENT CLAUDICATION?

GUILLERON, C., BARDEAU, J.F., BEAUNE, B., MAKTOUF, W., HENNI, S., ABRAHAM, P., DURAND, S.

LE MANS UNIVERSITY

#### INTRODUCTION:

Development of atherosclerosis in lower limbs leads to peripheral arterial disease (PAD). During walking, patients may present intermittent claudication (PAD-IC) and therefore impaired walking due to ischemia and associated pain. Many different gait parameters are affected [1,2] and univariate analyses (involving a single variable at a time) of this large number of parameters is a long process which can lead to a various number of interpretations. Therefore, the aim of this study is to check whether an approach using principal component analysis (PCA) can reveal the relationship between parameters and specifically identify those which should be preferentially be considered when aiming at understand the impact of pain on gait parameters in PAD-IC patients.

#### METHODS:

We analyzed data from 7 patients with unilateral PAD-IC and 6 with bilateral PAD-IC. Data were recorded during a walking test on an instrumented treadmill and patients were asked to described development of pain. After standardization (i.e. scaling) of the recorded parameters, a PCA approach was used to reduce the dimensionality of the multivariate data and to objectively determine which variables were most affected in the process associated with the onset of pain.

#### RESULTS:

The moment when patients described pain appearance fit perfectly with characteristic gait changes identified by PCA. In addition, PCA revealed that some parameters affected depend on PAD extent. Specifically, patients with unilateral PAD-IC had altered parameters in the symptomatic leg when pain occurred (such as an increase of the oscillation phase of the gait cycle, a decrease of the propulsive forces) while in case of bilateral PAD-IC, plantar forces decrease bilaterally. PCA also highlighted additional individual changes (such as step width) suggesting that an individual adaptation to pain is also at stake.

#### CONCLUSION:

PCA highlighted that some parameters are commonly affected by the development of pain in PAD-IC patients but the extent of PAD has to be considered. When studying gait alterations in PAD-IC patients, we now recommend focusing on these parameters. Since some other parameters are also affected individually, PCA can also be used to identify which ones must be taken into account when adapting the rehabilitation strategy based on physical activities.

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### EFFECTS OF A SEDENTARY BEHAVIOR REDUCTION INTERVENTION ON COMMON CARDIOMETABOLIC RISK FACTORS IN METABOLIC SYNDROME PATIENTS – A RANDOMIZED CONTROLLED TRIAL

GARTHWAITE, T.1, SJÖROS, T.1, LAINE, S.1, VÄHÄ-YPYÄ, H.2, SIEVÄNEN, H.2, LAITINEN, K.3, HOUTTU, N.3, LÖYTTYNIEMI, E.4, KALLIOKOSKI, K.1, VASANKARI, T.2, KNUUTI, J.1, HEINONEN, I.1

1:TURKU PET CENTRE, UNIVERSITY OF TURKU AND TURKU UNIVERSITY HOSPITAL 2:UKK INSTITUTE 3:INSTITUTE OF BIOMEDICINE, UNIVERSITY OF TURKU 4:DEPARTMENT OF BIostatISTICS, UNIVERSITY OF TURKU

#### INTRODUCTION:

Sedentary behavior (SB) has been postulated to be an important risk factor for many common chronic diseases such as cardiovascular disease and type 2 diabetes. Previous studies on the health effects of SB have been mainly observational epidemiological studies or short

interventions. The purpose of this long-term intervention study was therefore to investigate whether only reducing SB could improve metabolic health in subjects at high risk for cardiometabolic diseases.

#### METHODS:

Sixty-four subjects with metabolic syndrome (mean age 58, SD 7; 37 women) were randomized into intervention and control groups (n=33 and n=31, respectively). The study lasted for 3 months and the intervention group was guided to reduce their sitting time by 1 hour a day by increasing their standing and light physical activity (PA), without increasing their moderate to vigorous PA. The control group was guided to maintain their normal SB and PA habits. At baseline and after the intervention waist circumference and blood pressure (BP) were measured, fasting blood samples were analyzed and body composition was determined by air displacement plethysmography (Bod Pod). A linear mixed model was used to detect differences between groups and over time. There was only 1 drop-out leaving 63 subjects to the analysis.

#### RESULTS:

At 3 months both intervention and control groups showed a significant effect of time as a decrease in body fat percentage [-1.0 (SD 1.8) and -1.0 (3.3) %, respectively,  $p = 0.004$ ], systolic BP [-5 (15) and -3 (12) mmHg,  $p = 0.02$ ], diastolic BP [-2 (7) and -4 (8) mmHg,  $p = 0.01$ ] and waist circumference [-1.5 (4) and -0.8 (3) cm,  $p = 0.01$ ]. Both groups also showed a significant effect of time as an increase in fasting plasma glucose [0.2 (0.5) and 0.3 (0.3) mmol/l,  $p < 0.001$ ], total cholesterol [0.4 (0.5) and 0.4 (0.5) mmol/l,  $p < 0.001$ ], LDL cholesterol [0.3 (0.4) and 0.3 (0.4) mmol/l,  $p < 0.001$ ], and HDL cholesterol [0.1 (0.1) and 0.1 (0.2) mmol/l,  $p < 0.001$ ]. A significant group x time interaction was observed as an increase in control group's fasting insulin [5 (6) mU/l,  $p < 0.001$ ], triglycerides [0.2 (0.4) mmol/l,  $p = 0.05$ ], glycated hemoglobin HbA1c [1 (2) mmol/mol,  $p = 0.01$ ], and liver enzymes P-ALAT [8 (11) U/l,  $p = 0.004$ ] and P-ASAT [7 (10) U/l,  $p < 0.001$ ], which were all maintained at baseline levels in the intervention group.

#### CONCLUSION:

It can be concluded that guiding metabolic syndrome patients to reduce their daily sedentary behavior without formal physical activity seems effective in maintaining their fasting insulin, triglyceride and HbA1c levels when compared to the control group. Further, participating in a reduced sedentary behavior intervention trial was beneficial for both groups in reaching more favorable body composition and waist circumference, and lowering blood pressure. However, the sedentary behavior reduction intervention without an exercise component appears not to be effective in preventing an increase in plasma glucose or cholesterol levels that occur over time.

## IS-SP01 TOKYO CALLING: BEATING THE HEAT - SPONSORED BY GSSI

### HOW HOT IS TOO HOT? EXTREME HEAT POLICY DEVELOPMENT AND IMPLEMENTATION FOR ELITE SPORTS COMPETITION

JAY, O.

UNIVERSITY OF SYDNEY

With a few notable exceptions, fatal heat-related injury during elite sport competition is mercifully rare. Nevertheless, exertional heat illness is a very real concern even for professional athletes in peak physical condition. Examples of high-profile heat illness incidents in elite sports have been seen in cricket, rugby league, American football, and tennis, to name a few.

Some commentators have suggested that play of various sports should be suspended at a fixed ambient air temperature. However, the factors contributing heat stress risk of an athlete are far more extensive. Ambient temperature is measured in shade and therefore does not adequately represent the net thermal stress that a person is exposed to. Black globe temperature, which can be 12 to 15°C higher than air temperature, helps assess the thermal load that can be attributed to direct, diffuse and reflected solar radiation. Ambient humidity determines the drive for sweat evaporation, which is the most important (and often the only) physiological heat loss mechanism in hot environments. Higher levels of air movement, which can be both environmental and self-generated, promotes sweat evaporation in humid conditions, and when air temperature is lower than ~35°C, can augment dry heat loss via convection. Even under a fixed set of environmental parameters, heat stress risk is further modified by the level of athlete exertion, and the extent to which clothing and/or protective equipment acts as a barrier to heat dissipation at the skin surface.

The implementation of an evidence-based extreme heat policy for a given sport requires the accurate quantification of, preferably, all four environmental parameters described above. If an event takes place in a setting likely to create a micro-environment, conditions should be measured in situ. Whichever heat stress index is embedded within a given heat policy, exposure thresholds should be set according to physiological (e.g. acclimation status, aerobic fitness) and biophysical (e.g. body size) characteristics of the athletes competing, and the level of risk that a competitor can be expected to tolerate. The output of this index should be presented in an interpretable format for a range of users without specialist knowledge. Finally, strategies implemented to mitigate heat stress risk during competition upon reaching a given heat stress threshold should be feasible and compatible with the temporal profile of the sport and should be recommended based on scientific evidence of their efficacy.

Examples of the development and implementation of novel extreme heat policies by our research team for professional sports (Rugby League, Tennis, Cricket) will be presented.

### HYDRATION RESEARCH: IMPLICATIONS FOR EXERCISE IN THE HEAT

JAMES, L.

LOUGHBOROUGH UNIVERSITY

Exercise increases metabolic heat production, with sweat rate increasing to augment heat loss, and moderate increases in core body temperature. When exercise takes place in the heat, these sweat losses can be substantial (>4 L/h in some athletes). Fluid intake of athletes during exercise, at least prolonged moderate or high-intensity exercise, is rarely sufficient to match sweat losses, meaning that some degree of dehydration develops during exercise. Typically, most athletes undertaking prolonged exercise, particularly in a warm/ hot environment, encounter mild/ moderate dehydration (sweat loss equal to 1-5% body mass). The impact of dehydration on physiological and performance responses during exercise has been extensively studied over the past century, representing one of the oldest research areas in exercise physiology/ sport nutrition. Despite this, the question of whether dehydration, at least a level experienced by athletes, influences human performance remains hotly debated. The general consensus is that dehydration equivalent to >2% body mass impairs endurance performance in temperate, warm and hot environments, although some studies report lower levels of dehydration to impair performance. In particular, dehydration appears to have a more deleterious effect on endurance performance in the heat, making it a key

consideration for exercise in such environments. Whilst dehydration has clear effects on physiological function that provide a strong mechanistic basis for how dehydration might impact exercise capabilities, methodological limitations inherent in almost all dehydration studies mean it is difficult to make robust conclusions about effects on performance. The main methodological limitation is that, unlike in other areas of sport nutrition research, where treatments are typically blinded from subjects using a placebo, studies on dehydration have generally not blinded subjects from the intervention/ their hydration status. This means it is possible that the subject's knowledge of the treatment they are receiving (hydration or dehydration) could have an influence on their performance, out with any real effect of dehydration. This means much of the literature on dehydration and human performance might be confounded, which is certainly a factor contributing to some of the debate in the area. In recent years, researchers have tried to remedy this methodological flaw and this presentation will outline the results of these recent studies, as well as other issues with hydration methodology, and present novel data exploring the effect of dehydration on endurance exercise performance, with a particular focus on exercise in the heat.

## **PRACTICAL STRATEGIES TO BEAT THE HEAT — RECOMMENDATIONS FOR HEAT ACCLIMATION BY POST-EXERCISE HOT BATH**

WALSH, N.P.

LIVERPOOL JOHN MOORES UNIVERSITY

Practical strategies to beat the heat — recommendations for heat acclimation by post-exercise hot bath

Neil P. Walsh FACS, @ProfNeilWalsh

Research Institute for Sport and Exercise Science, Liverpool John Moores University, United Kingdom.

Exercise in the heat increases physiological strain, decreases exercise performance and increases susceptibility to exertional heat illness. Current recommendations are for athletes and others in occupations involving high heat exposure to complete a period of heat acclimation prior to competing or operating in the heat. Heat acclimation typically involves exercising in the heat on 5–14 occasions for >60 min, where core body temperature and skin temperature are elevated and profuse sweating is initiated. Despite compelling evidence that exercise-heat-acclimation alleviates thermal strain and improves performance in the heat, only 15% of athletes heat acclimatized as part of their preparation for the 2015 World Athletics Championships in the heat and humidity of Beijing. Likely reasons include the belief amongst some athletes that their high training status protects them from performance decrements in the heat (viz. partial heat acclimation) and conventional exercise-heat-acclimation protocols can be costly, impractical and interfere with the athlete's training and taper. This has prompted the search for more practical heat acclimation strategies including hot water bathing after exercise ("train-cool, bathe-hot"). This presentation will focus on my team's recent work showing that taking a hot bath (40°C water) for up to 40 min after exercise for six days reduced both resting and exercising core body temperature and improved running performance in the heat (~5%, 5km TT). The recovery hot bath takes advantage of the rise in core body temperature during exercise in temperate conditions; with the additional and sustained increase in body temperature during the hot bath (~1°C; 20–40 min immersion) and the clamped skin temperature triggering hallmark heat acclimation adaptations. The findings of a subsequent series of studies on this novel heat acclimation strategy will be presented answering important questions such as: do post-exercise hot baths provide heat acclimation for highly trained athletes?; are the benefits comparable with conventional exercise-heat-acclimation?; how long do the heat acclimation benefits last?; is it necessary to complete 6 days of post-exercise hot baths, and is more better? The presentation will also provide important safety recommendations for athletes and support staff adopting post-exercise hot baths for heat acclimation and explore the possibility of further benefits to athlete health.

## **OP-PN14 INTERVAL TRAINING; RESPIRATION; THERMOREGULATION**

### **HEAT-AND-MOISTURE EXCHANGING MASKS: ADVANTAGE OR HINDRANCE DURING EXERCISE IN SUB-ZERO CONDITIONS?**

TUTT, A., PERSSON, H., ANDERSSON, E.P., AINEGREN, M., STENFORS, N., HANSTOCK, H.G.

MID SWEDEN UNIVERSITY

#### **INTRODUCTION:**

Heat-and-moisture exchanging masks (HMEs) are commonly used by athletes experiencing cold-air induced airway obstructions such as exercise-induced asthma to negate symptoms in training and competition. These masks have been demonstrated as an effective intervention at wide ranging intensity levels and duration for preventing airway obstructions (3). A large proportion of cross-country skiers experience asthma symptoms whilst training and competing in cold conditions (1, 2). As large numbers of athletes in cross country skiing and other outdoor winter endurance sports train and compete in cold conditions around the globe, links have been inferred between prolonged cold air inhalation and the development of exercise-induced asthma (2). The aim of this study was to investigate the effect of an HME on the performance (defined as distance completed) of healthy people during a maximal self-paced exercise test.

#### **METHODS:**

Twenty-three healthy, well-trained participants (eight females, 15 males; age 18-53 y) performed two simulated competition efforts at -15 degrees Celsius in randomized order either with or without mask first. The protocol was 5 min each at 65, 70 and 75% of VO<sub>2</sub> Max followed by 3 min at 90% VO<sub>2</sub> Max and a further 12 min at 65% before a 5 min pause to simulate a competition warm up followed by a 4 min maximal self-paced running test. A t-test was performed to compare performance outcomes. Two-way repeated measures ANOVA was used to examine effects of trial order and gender on performance. Linear regressions were used to investigate relationships between key physiological and biometric data and the effect of the HME on performance. All statistical analyses were performed with R using the jamovi interface. The study was conducted according to the declaration of Helsinki and approved by the regional ethics committee.

#### **RESULTS:**

Participants ran significantly further without HME (Mean: 931m, SD: 106m) than with HME (Mean: 918m, SD: 110m,  $p=0.039$ ). No significant effect of trial order was observed ( $p=0.816$ ). Body mass negatively correlated with the magnitude of the effect of the mask on performance; participants with higher body mass had a greater negative effect of the mask ( $r_2 = 0.215$ ,  $p=0.026$ ). No relationships were found between the effect of the HME and sex, age, ventilation, absolute or relative VO<sub>2</sub>peak.

#### **CONCLUSION:**

Our findings suggest that HME usage hinders maximal running performance in healthy subjects to an extent that may be sufficient to alter competition outcomes. Potential effects of sex, body mass and performance level should also be investigated further.

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### **SPRINT-INTERVAL EXERCISE, BUT NOT MODERATE INTENSITY CONTINUOUS EXERCISE, DISRUPTS THE MITOCHONDRIAL POOL AND INCREASES THE REGULATION OF MITOPHAGY.**

BOTELLA, J., JAMNICK, N.A., PERRI, E., SANER, N.J., DIAZ-LARA, J., OORSCHOT, V., RAMM, G., LAZAROU, M., BISHOP, D.J.  
VICTORIA UNIVERSITY

#### **INTRODUCTION:**

Endurance exercise is a powerful metabolic stimulus affecting the dynamic regulation of mitochondria. However, it is still debated the effects of different types of exercise on mitochondrial adaptations. A greater understanding of the biological mechanisms responsible for the exercise-induced adaptations is critical for the development of more effective exercise interventions. Therefore, the aim of this study was to explore the effects of two widely used exercise prescriptions on mitochondria.

#### **METHODS:**

Twenty-eight healthy male participants were randomly allocated into two exercise groups. All participants underwent 3 weeks of familiarisation prior to the experimental session. Moderate intensity continuous exercise (MICE;  $n = 14$ ;  $26 \pm 6$  y,  $24.1 \pm 2.6$  BMI) consisted of 90 min at  $\sim 40\%$   $W_{max}$  (Mean  $W = 127 \pm 38$ ;  $\Delta$  lactate  $0.44 \pm 0.24$  mmol/L; post-exercise pH =  $7.37 \pm 0.02$ ), sprint interval exercise (SIE;  $n = 14$ ;  $27 \pm 5$  y,  $23.7 \pm 2.8$  BMI) consisted of 6 x 30'' all-out sprints interspersed by 4 min of rest (Mean  $W = 579 \pm 107$ ;  $\Delta$  lactate  $9.86 \pm 1.88$  mmol/L; post-exercise pH =  $7.02 \pm 0.08$ ). Skeletal muscle samples were collected from the vastus lateralis before (PRE) and after (+ 0 h, + 1/1.5 h, + 2.5 h, and + 24 h) a standardised exercise session. A small fraction of the samples was immediately fixed and used for transmission electron microscopy (TEM), and the remaining was immediately frozen and used to study mRNA expression and protein phosphorylation levels.

#### **RESULTS:**

Post-exercise TEM micrographs from SIE samples showed  $\sim 15\%$  of abnormal mitochondria (e.g., decreased electron density, cristae density and/or disrupted outer membrane). This disturbance was not present in micrographs obtained at rest or after MICE, suggesting SIE was a stronger stimulus to damage mitochondria and initiate mitophagy. This was supported by a significant increase, only following SIE, in p-ULK1 at s555 ( $p = 0.007$ ), an essential phosphorylation site for mitophagy. General autophagy mRNA expression (increased GABARAP1;  $p < 0.05$ ), and protein content (increased LC3B-II;  $p < 0.05$ ) were similarly modified in both groups. However, a subset of genes involved in mitochondrial dynamics (MFN2, MIEF2, PARK2) were only significantly increased following SIE ( $p < 0.05$ ). Consistent with previous research, the mRNA content of genes regulating mitochondrial biogenesis (PGC1 $\alpha$ , PDK4, PPAR $\alpha$ ) was significantly elevated following both SIE and MICE ( $p < 0.05$ ).

#### **CONCLUSION:**

Early mitochondrial biogenesis signalling did not seem to differ between conditions. For the first time we report that SIE led to an increased mitochondrial structural disturbance, which preceded the increase in p-ULK1 at s555. Together with the increase in the mRNA expression of some genes that regulate mitochondrial dynamics, this suggests that SIE promotes an increased mitochondrial-specific quality control. The present results expand on the biological mechanisms regulating adaptation to exercise and may lead to improved exercise prescription.

### **THE EFFECT OF HIGH-INTENSITY INTERVAL TRAINING ON THE RENIN-ANGIOTENSIN SYSTEM SIGNALING IN SKELETAL MUSCLE OF OVERWEIGHT AND OBESE MEN AND WOMEN**

PEREZ-VALERA, M.1, MARTIN-RODRIGUEZ, S.1, LARSEN, S.2, MARTINEZ-CANTON, M.1, DOLHMAN, T.2, MARTIN-RINCON, M.1, SØNDERGAARD, S.D.2, MORALES-ALAMO, D.1, DANIELSEN, J.2, PONCE-GONZALEZ, J.G.1

1 IUIBS AND ULPGC, SPAIN; 2 UNIV. OF COPENHAGEN, DENMARK; 3 NIH, OSLO

LOSA-REYNA, J.1, PEREZ-SUAREZ, I.1, HELGE, J.2, CALBET, J.A.1,3

#### **INTRODUCTION:**

Overactivation of the renin-angiotensin (Ang) system (RAS) has been recently associated with fat accumulation and loss of skeletal muscle mass, common hallmarks of obesity. Angiotensin-converting enzymes (ACE1 and ACE2) catalyse the conversion of Ang to Ang II, which via both Ang II receptors (AT1R and AT2R) modulate ROS, inflammation and may contribute to muscle loss and maintenance. The role of exercise training on the regulation of skeletal muscle RAS signalling remains unknown. Thus, we aim to ascertain how high-intensity training (HIT) modulates RAS signalling in skeletal muscle of overweight and obese individuals and its influence on the changes in body composition.

#### **METHODS:**

Forty-one women (age: 31 yo, weight: 87.1 kg) and 50 men (age: 28.3 yo, weight: 100.9 kg) with overweight or obesity (BMI > 27 kg/m<sup>2</sup>) participated in a HIT program (3 sessions/week x 6 weeks, each consisting in 7 bouts of 1min cycling at 100% of VO<sub>2</sub>max, with 1 min recovery between bouts or five bouts at a higher intensity with 90s recovery in between). In each volunteer muscle biopsies from vastus lateralis were obtained before, 72h after the last training session, and after 3 weeks of detraining. ACE1, ACE2, AT1R and AT2R protein expression were analysed by Western Blot. Body composition was assessed by DXA. Statistical analysis: repeated-measures ANOVA.

#### **RESULTS:**

VO<sub>2</sub>max and maximal power output were improved significantly after training (5-10%), while arterial blood pressure was slightly reduced. The protein expression of AT1R was increased by 13% after HIT ( $P=0.017$ ,  $n=71$ ) and remained at this level after 3 weeks of detraining ( $P=0.019$ ). AT2R protein expression was increased after HIT by 33% ( $P=0.035$ ,  $n=32$ ), returning to pre-training levels after 3 weeks of detraining. No significant changes were observed in the protein expression levels of ACE1 and ACE2. Men and women responded similarly to HIT (all training variables x sex interactions  $P>0.10$ ). No significant differences between sex were observed in the protein expression levels of ACE1, ACE2, AT1R and AT2R.

#### **CONCLUSION:**

Increased expression of AT1R and AT2R could facilitate Ang II signalling in skeletal muscle. Some recent studies indicate that the pharmacological blockade of Ang II Receptors may facilitate muscle regeneration, muscle insulin sensitivity and reduced disuse-related atrophy. In turn, increased Ang II signalling in skeletal muscle has been associated with oxidative stress. Given the intensity of the exercise performed



and the exhaustive nature of the training program, we cannot rule out these changes as indicative of potential maladaptation to this model of training.

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## **PS-PL02 SPRINT PERFORMANCE: BEATING THE LIMITS**

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### **THE PHYSIOLOGICAL DETERMINANTS OF SPRINT PERFORMANCE: AN INTEGRATIVE APPROACH**

CALBET, J.

*UNIVERSITY OF LAS PALMAS DE GRAN CANARIA*

Sprint performance is critical for success in many sports. A high-level sprint performance requires the optimal application of force to produce the highest power output possible. In many athletic events, the time available to generate force is very short (<75 ms), and therefore the capacity to produce high power since the very beginning of contractions is crucial for performance. Neural, muscular and mechanical factors influence the ability to generate outstanding levels of power. Several approaches trying to isolate the role played by each factor have been undertaken. However, there is lack of experimental evidence on how the three components interact to limit performance and how they respond to changes in stimulation (training/detraining) under varying circumstances (duration of contractions, temperature, fatigue, etc.). The force exerted at any given time depends on the number of cross-bridges generating tension. On the other hand, the shortening velocity depends mostly on the speed at which myosin detaches and re-attaches to actin, whose primary determinant is the myosin ATPase activity. The neural component should produce synchronised activation of all motor units at the highest frequency possible during explosive muscle contractions, with timely activation of the agonist and antagonist/synergist muscles. A higher proportion of myosin heavy chain (MCH) IIX is associated with greater force and shortening velocity, a distinctive quality of the faster mammals in nature. The quicker and larger Ca<sup>2+</sup> transients of type II fibers are also contributing factors, which may become more critical as fatigue develops. Calcium transients are sensed by the calcium decoding proteins, namely Ca<sup>2+</sup>/calmodulin-dependent protein kinase II (CaMKII) and calcineurin. Increased CaMKII phosphorylation may induce muscle hypertrophy and reduce muscle breakdown by downregulation of the ubiquitin E3 ligases. Paradoxically, MCH IIX increase with immobilization and decrease with exercise training. Although the most effective strategy to improve muscle power is by loaded contractions performed at the highest speed possible (explosive-type strength training), the level of fatigue reached during each set has a major impact on muscle adaptations. Reducing the level of fatigue allowed during the training session helps to preserve MCH IIX and is associated with greater improvement in jumping and sprinting performance. In vitro experiments indicate that muscle contractions to failure are associated with increased reactive oxygen species production, which reduces Ca<sup>2+</sup> release and Ca<sup>2+</sup> sensitivity, thus hampering peak power output. During prolonged sprints, as well during repeated short sprints, the mechanisms limiting performance become more complex and will be analysed with some detail. The inclusion of ergogenic aids and adequate training may help to overcome some of the limitations.

### **NEW THOUGHTS ON DEHYDRATION, ADAPTATION AND PERFORMANCE: HOW SHOULD ATHLETES ADDRESS FLUID NEEDS DURING SPORT?**

BURKE, L.

*AUSTRALIAN INSTITUTE OF SPORT*

Early research on the effect of dehydration on performance concluded that a fluid deficit above a threshold equivalent to ~2% BM was sufficient to impair performance, particularly in hot conditions. However, there have been recent challenges to this notion. Issues speaking to the overestimation of the effect of dehydration include the failure of laboratory based studies to account for real world conditions or the "placebo" effect of drinking, as well as the observation that many athletes incur substantial fluid deficits during "winning" performances. On the other hand, the small margins between winning and losing, the effect of dehydration on the "mental cost" of performance in events requiring repeated efforts, and the central nervous system benefits associated with oral sensation of fluid intake or cooling provide an incentive for a proactive fluid plan. Novel research protocols are attempting to remove some of these previous biases in their investigation of the effects of dehydration on sports performance, while other investigations are comparing "planned drinking" versus "drinking to thirst" as the underpinning theme of fluid practices. Whether repeated exposure to exercising in a dehydrated state "trains the body" to tolerate a fluid deficit or leads to a reduction in training quality and adaptation is a relevant question for athletes who are deliberately preparing for hot weather competition.

14:00 - 16:00

## IS-PN09 ANTIOXIDANT SUPPLEMENTS IN SPORTS NUTRITION: MOLECULAR AND PHYSIOLOGICAL PERSPECTIVES

### REDOX BASIS OF EXERCISE PHYSIOLOGY AND ANTIOXIDANT SUPPLEMENTATION

NIKOLAIDIS, M.G.

*ARISTOTLE UNIVERSITY OF THESSALONIKI*

Biology is rich in claims that reactive oxygen and nitrogen species are involved in every biological process and disease. However, many aspects of redox biology remain elusive. Similarly, despite intense research efforts, it is still uncertain whether and how antioxidants affect redox homeostasis and performance. I believe that the main reason for the failure of antioxidant supplements to decrease oxidative stress and promote performance is the fact that antioxidant supplements have been administered in humans with normal levels of oxidative stress biomarkers and antioxidants. In fact, our group has shown that the beneficial effects of antioxidant supplementation are restricted to individuals with high baseline levels of oxidative stress (eg, F2-isoprostanes) and/or low antioxidants (eg, vitamin C and N-acetylcysteine). Another crucial reason explaining the general failure of antioxidant supplements is the neglect of basic chemical kinetics. The important quantitative parameters needed to consider to address the feasibility of redox and antioxidant reactions in vivo are: rate of formation and consumption of a reactive oxygen and nitrogen species, half-life, diffusibility and membrane permeability. In the first part of my presentation, I will explain the basic chemical kinetics concepts and mathematical calculations required to perform "street fighting" quantitative analysis. In the second part, I will provide key numbers to help think about sizes, concentrations, rates and other important quantities that describe the major oxidants (superoxide, hydrogen peroxide, nitric oxide) and antioxidants (vitamin C, vitamin E, glutathione). In the final part, I will try to i) refine the broad understanding of this research area, ii) provide suggestions for designing better studies and iii) define more efficiently the "borders" between cellular signaling and stress. Based on this analysis, I will attempt to argue that redox regulation should be acknowledged as central to exercise physiology and sports nutrition.

### THE ROLE SUPPLEMENT TYPE ON FREE RADICAL BIOCHEMISTRY AND THE NEED FOR A STANDARDIZED APPROACH TO BETTER UNDERSTAND THIS EXTREMELY COMPLEX BIOMATRIX.

FOGARTY, M.

*UNIVERSITY OF HULL*

There is extensive debate related to the complex biochemistry of free radical species and their role in the exercise continuum. Often cited as a negative protagonist of exercise stress, there has been widespread research attempting to offset this stress through the use of antioxidant supplement strategies. More recently free radicals - and the stress they cause - are now thought to be a key signalling mechanism in the process of physiological adaptation we associate with regular physical activity/exercise. In line with this area of research, it is thought that antioxidant supplements may provide too much protection to the exercise stimulus and thus potentially blunt any adaptation. As a countermeasure natural food sources high in antioxidants have been investigated for their capacity to bolster normal antioxidant levels without blunting the hormesis response. The complexity of this area of research is further compounded by the lack of clear sensitive biological end points that can be measured in a series of projects across research groups in order to build consensus within the data. Therefore, the purpose of the presentation will be to 1) review current research findings in order to highlight the range of pharmacological and food supplements, 2) add perspective to the range of biological markers used to evaluate oxidative stress and the level of variation within the end points and 3) present experimental evidence for the potential use of an exercise modality as a method for delivering a consistent "dose" of free radical stress.

### PHYTONUTRIENTS AND RECOVERY FROM EXERCISE-INDUCED MUSCLE DAMAGE

CLIFFORD, T.

*LOUGHBOROUGH UNIVERSITY*

Phytonutrients are natural compounds found in plant foods, which are purported to provide benefits for human health. Phytonutrients not only have anti-inflammatory and antioxidant properties but also act as stimulators of cell signalling pathways. Emerging literature has suggested that phytonutrients provided in foods and supplements such as tart cherries and curcumin may improve exercise recovery, particularly following muscle-damaging exercise. The use of phytonutrients to support training and recovery has become increasingly more popular with recreational exercisers and athletes and therefore there is growing interest in the scientific evidence to support their use. There is, however, some concern that antioxidant supplementation may actually blunt adaptation to both endurance and eccentric based exercise and the effects of consuming phytonutrient-rich foods following exercise on subsequent adaptation has not fully explored. Large variations in study design, including supplement dose and duration, exercise type and biomarkers measured has meant that contradictory evidence is presented in the literature. Furthermore, the mechanisms underpinning the beneficial effects reported with many of these supplements are not well understood. This presentation will review the current literature on the use of the most common and potentially beneficial phytonutrient-based supplements during recovery from exercise-induced muscle damage and make recommendations for how research in this area can be improved.

## IS-BM03 THE AGING TENDON

### THE AGING TENDON AT THE NANOSCALE

SVENSSON, R.

UNIVERSITY OF COPENHAGEN

In tendon the collagen is organized at several different length scales, and the basic building block is found at the nanoscale in the form of collagen fibrils. The bulk of tendon collagen shows practically no turnover after skeletal maturity, which on one hand could suggest limited changes with age, but also makes the tissue susceptible to accumulated insult over long time. With age, a number of changes have been reported in tendon collagen, including increased molecular spacing within the fibrils (1) and reduced solubility (2), both of which may be related to biochemical changes that also take place with age. These biochemical changes include a continuous accumulation of Advanced Glycation End-products (AGEs), which result from binding of reducing sugars and certain reactive metabolic compounds to the collagen.

Some of these AGEs can form covalent bonds (cross-links) within and possibly between collagen fibrils, which may affect the collagen's mechanical function. At the macroscopic scale, *in vitro* studies show increased tendon mechanical strength and stiffness with artificially induced cross-linking (3), and studies at the nanoscale suggest similar changes as well as reduced sliding between fibrils, indicative of interfibrillar bonds also being formed (1). Because these AGEs accumulate *in vivo* over time, similar changes would be expected with age, however, both *in vitro* and *in vivo* studies on human and animal tendons suggest either no change or a reduction in mechanical properties at a macroscopic level (4).

The reason for this discrepancy is unclear, and little is known about mechanical changes at the nanoscale with age. To investigate this we recently conducted a study with the hypothesis that cross-linking may result in brittleness at the fibril level. Brittleness represents an inability to absorb energy due to reduced stretchability, and would make the fibrils more susceptible to accumulation of micro-damage, which in turn could compromise macroscopic mechanical function. Our study looked at collagen fibrils from the patellar tendon of young (26 ±4 years) and old (65 ±1 years) men and women and showed increases in stiffness and strength, just as expected with increased cross-linking. However, the stretchability of the fibrils was unchanged and the ability to absorb energy was increased rather than decreased. The nanoscale mechanical function of collagen fibrils therefore did not help explain the apparent reduction in mechanical function with age at the macroscopic level. Due to the technical challenges only few studies have investigated mechanics at the fibril level and further basic research is still required to understand how mechanical and structural changes at the nanoscale translate to tissue function.

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### THE AGING TENDON IN AN ANIMAL MODEL

THORPE, C.

ROYAL VETERINARY COLLEGE

It is well established that tendon injury risk increase with age, particularly in tendons with an energy storing function, such as the human Achilles tendon, but the underlying mechanisms remain unclear. We have explored age-related susceptibility to injury by characterising structure function relationships, and how these alter with ageing, in the equine superficial digital flexor tendon (SDFT). The SDFT shares many similarities with the human Achilles tendon, in terms of tendon structure and function, and epidemiology and aetiology of disease, making it an excellent model in which to study tendon ageing. Using this model, we have identified several structural specialisations that provide the optimised mechanical properties required for efficient energy storage. Further, we have identified age-related deterioration in these specialisations which likely relate to increased injury risk.

Our work has highlighted the importance of a specific component of tendon, the interfascicular matrix (IFM) in the healthy function of energy storing tendons. The IFM is a loose, glycoprotein-rich matrix that binds adjacent fascicles together within the tendon. In the SDFT, we have shown that the IFM allows sliding between adjacent fascicles, providing the capacity for greater tendon extension which is required for efficient energy storage (1). We have demonstrated that the IFM has a specialised composition, rich in elastin and lubricin, which provides enhanced elasticity and fatigue resistance (2-5). In addition, we have measured greater capacity for protein turnover in the IFM compared to the fascicles, which may be a mechanism to repair microdamage in this region.

With ageing, we have shown that the IFM in the SDFT becomes stiffer and less able to resist cyclic loading. This is accompanied by a reduction in elastin content and organisation, and decreased rate of protein renewal within the IFM (2,4,5). These changes likely contribute to the increased injury risk to the SDFT observed with increasing age. However, the mechanisms that result in the age-related deterioration of IFM structure and mechanical properties are yet to be determined.

Taken together, these data highlight the importance of the IFM in the function of energy storing tendons such as the equine SDFT, and identify age-related alterations in IFM structure and function that likely contribute to increased injury risk. However, there are important questions that need to be answered to fully understand the mechanobiological mechanisms that govern tendon homeostasis and how these are affected by ageing.

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## THE AGING HUMAN TENDON FROM A FUNCTIONAL PERSPECTIVE: CAN THE EFFECTS OF AGING BE COUNTERACTED?

BOJSEN-MØLLER, J.

UNIVERSITY OF OSLO

In recent decades imaging techniques with high timewise and spatial resolution have evolved. Thus, the ability to measure structural mechanical properties in vivo of human tendons has increased. A significant number of studies have examined human tendon mechanical properties in

cross-sectional or longitudinal intervention designs, comparing effects of training regimes, loading, unloading and aging. At the macro-anatomic level also the understanding of in-vivo tendon loading and force transmitting function has increased although numerous questions remain unanswered. It

seems clear that added habitual loading such as strength training or exercise may induce modest changes in whole-tendon-tissue properties, while on the other hand unloading seems to rapidly reduce for example structural tendon stiffness. It appears that the force bearing tissues to some

extent adapt to loading 1, but at the same time, studies that in different ways examine tissue metabolism or turnover remain equivocal 2,3. Studies that compare young and old of similar activity levels find also group differences to suggest some tendon adaptation 4. Nonetheless the exact

underlying mechanisms at either micro- or macroscale level are not well understood. The present talk addresses how the human tendon as a functional structure adapts to aging and discusses if adaptations to aging per se are different from those that result from unloading or an inactive lifestyle. Moreover, it is discussed if habitual exercise can counteract potential negative functional adaptations to aging.

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## IS-AP02 NEW STRENGTH TRAINING METHODS

### STRENGTH TRAINING WITH BLOOD FLOW OCCLUSION: WHERE ARE WE NOW?

AAGAARD, P.

UNIVERSITY OF SOUTHERN DENMARK

Ischemic muscle exercise using low-to-moderate loading intensity (20–50% 1RM) with concurrent blood flow restriction (BFR) has received increasing attention both in the clinical rehabilitation setting as well as in the training of healthy athletes. BFR training appears to result in amplified hypertrophy responses and greater strength gains compared to resistance exercise using identical loads and volume without vascular occlusion (i.e. low intensity free-flow resistance exercise). Notably, gains in skeletal muscle mass and maximal muscle strength induced by BFR training may match or even exceed that observed with conventional types of heavy-resistance strength training.

Satellite cells (SCs) are undifferentiated muscle stem cells with the ability to re-enter the cell cycle to generate new muscle fibers and/or to provide new myonuclei to existing muscle fibers during the hypertrophy process. The activation and proliferation of myogenic SCs with resistance exercise have been suggested to play an essential role in conditions of amplified muscle protein synthesis by providing increased transcriptional capacity to the muscle cell.

Recent reports have demonstrated that BFR training can result in marked proliferation of SCs and myonuclear addition both in untrained individuals as well as highly trained strength athletes, thereby contributing to the accelerated time course and marked degree of myofiber hypertrophy that may be observed with this type of training. Thus, BFR training may represent an effective and non-pharmacological tool to increase the adaptive and regenerative capacity of human skeletal muscle. Consequently, low-load BFR training may be used to maximize skeletal muscle mass gains in strength and power athletes, as well as to prevent muscle loss in atrophic/sarcopenic patients including injured athletes.

Multiple causative mechanisms have been proposed for the hypertrophy response observed with BFR training, including amplified systemic testosterone and growth hormone levels, increased IGF-1 expression and reduced myostatin expression in trained myofibers, as well as high levels of metabolic myofiber stress during and following acute BFR exercise. In addition, recent data from our Lab suggest that NO formation during BFR may play a pivotal role for SC activation, in turn stimulating the upregulation in myonuclear number.

Contradictory data exist on the effect of BFR training on human tendon properties. While previous studies have reported no effect of BFR training on biomechanical tendon and aponeurosis properties, more recent observations indicate that low-load BFR training may lead to increased tendon stiffness in healthy individuals. Recent pilot data further suggest that low-load BFR training may be useful for the rehabilitation of Patella tendinopathy. Clearly, more research is needed into the potential effect of low-load BFR training in healthy and injured tendon tissue.

### STRENGTH TRAINING AFTER INJURY: TIMING AND PROGRESSION TO IMPROVE MUSCLE AND CONNECTIVE TISSUE REGENERATION

BAYER, M.L.

INSTITUTE OF SPORTS MEDICINE COPENHAGEN, DEPARTMENT OF ORTHOPEDIC SURGERY M, BISPEBJERG HOSPITAL AND CENTER FOR HEALTHY AGING

Muscle strain injuries are classified as traumatic injuries that require substantial clinical rehabilitation to return to normal preinjury sports activity. These injuries have a high incidence and a significant reinjury rate. Besides re-injury, muscle strain injuries are associated with long-term pain, decline in sport-specific function and preterm end of sports careers. Strain injuries affect the muscle-connective tissue (tendon/aponeurosis interface), which implies that the tissue damage involves both contractile muscle and the connective tissue. In general, the regenerative capacity of connective tissue is often incomplete and adaptation to a stimulus slower in comparison to skeletal muscle. This difference has important implications for both prevention and rehabilitation of strain injuries.

Assessment of muscle function and structure by several imaging techniques are outlined. To investigate cellular changes after an injury, different molecular methods and in vitro studies are introduced and discussed.

An early onset of rehabilitation is crucial for the recovery period, most likely due to detrimental effects of unloading on cells in both the muscle and connective tissue. Interestingly, despite a gradual progression in loading during rehabilitation, persistent muscle atrophy of the injured muscle is seen without any apparent improvement over time. How could the loss of muscle tissue be prevented or blunted? Specific heavy strength exercises might be beneficial to stimulate muscle and connective tissue resident cells. Heavy loading might also have a positive effect on long-lasting inflammation after a strain injury. On the long term, fibrotic changes of strain injured muscles are detected with substantial intra- and intermuscular fatty infiltration. Could heavy strength training prevent and/ or reverse these pathological signs? Recent findings might clarify some of these questions.

### VELOCITY-CONTROLLED STRENGTH TRAINING

GONZÁLEZ-BADILLO, J.J.

UNIVERSIDAD PABLO DE OLAVIDE

Training load control is a key factor for the development of sports training methodology. Traditionally, in strength training, the typical references to determine intensity have been one-repetition maximum (1RM) and maximum number of repetitions against a given load (XRM). But these two variables present some drawbacks. Mainly, 1RM is modified during the training period, and most of the times it is measured poorly. Only these two special circumstances cause a misinterpretation of training effects, because it is thought that the effect obtained is due to the application of certain intensities, which could be wrong. As for XRM, there is a main problem: performing the same XRM does not mean that two or more people train with the same intensity, because the number of maximum repetition that can be performed with the same relative intensity can vary greatly from one person to another. This problem leads us to the same misinterpretation of the results as with 1RM, each person performs a different training, and nobody knows the relative intensity that caused a given effect. But the problems do not end here, since, for a same relative intensity, the fatigue or level of effort can be very different. In this sense, it is usual to prescribe a certain number of repetitions per set. And here we have a new problem, because performing the same number of repetitions for the same relative intensity does not mean the same effort for all people.

It seems obvious that these problems must be solved if we want to improve our training methodology. The solution to these problems is to achieve high accuracy in the prescribed relative intensity and the degree of effort in each set. These two objectives will be reached if we know the own velocity of each percentage of 1RM [1, 2] and the velocity loss in the set, which determines the degree of effort or fatigue [3, 4]. This decisive knowledge had never existed before. The lack of control of this variable turns it into a strange variable, that, without doubt, has traditionally prevented knowing the actual intensity that produces a given effect.

Therefore, the information derived from the velocity of the first repetition together with the velocity loss in the set can probably provide the best information about the degree of effort and fatigue of the training session. We understand that this type of information is the most important and accurate to be able to carry out an analysis of the true load that has caused a certain effect. Consequently, if velocity can be measured, the relative intensity will be determined by the velocity of the first repetition in the set, and the repetitions in the set should never be programmed, but the loss of velocity in the set.

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## IS-SH08 FEPSAC INVITED SESSION: HOW CAN YOU PROVIDE PSYCHOLOGY SUPPORT TO ENDURANCE ATHLETES? REACH, RELATIONSHIPS, IMPACT

### DO BRIEF INTERVENTIONS HELP ATHLETES RUN CALMLY?

BRICK, N.

ULSTER UNIVERSITY

In the final presentation, we will present the findings of a study on the effects of brief-contact relaxation interventions on performance time, physiological, perceptual, and attentional focus responses during 3km running. Previous research has supported the beneficial effects of relaxation training on endurance performance. The primary aim of this study was to determine the effects of brief-contact relaxation interventions on running performance outcomes. We also set out to explore the acceptability and perceived usefulness of these interventions. Thirty-nine trained endurance runners were randomly assigned to one of four conditions and visited the laboratory on four separate occasions. Here we will present data from three of those visits. Following a VO2max test (visit 1), participants completed two self-paced 3km time-trials separated by a four-week period. Following time-trial one (TT1; visit 2), participants received a brief-contact intervention consisting either of i) progressive muscle relaxation plus relaxation cues during running (PMR+RC), ii) relaxation cues only during running (RC), iii) smiling cues during running (SC), and iv) a concentration grid control (CC). Participants were asked to practice their intervention during the four weeks between laboratory visits 2 and 3. Participants completed a second 3km time-trial (TT2) during visit 3. Findings suggest that participants adopted different pacing strategies during TT2, with PMR+RC beginning at a slower relative speed during TT2 than TT1, and SC beginning at a faster relative speed during TT2 than TT1. Differences in final TT1 and TT2 completion times were not significantly different, however (Trial\*Condition interaction;  $p = .19$ ). Heart rate responses did not differ significantly (Trial\*Condition interaction;  $p = 0.41$ ). Changes in perceived effort mirrored changes in running speed but did not reach statistical significance (Trial\*Condition interaction;  $p = .06$ ). Participants reported an increased use of active self-regulatory strategies during TT2 than TT1 ( $p = .04$ ). Each group strongly agreed that their intervention was delivered in an acceptable manner and agreed that it was useful to their running performance. In this presentation we will discuss the implications for delivering brief-contact relaxation interventions to endurance participants.

## HOW PSYCHING TEAMS CAN HELP ENDURANCE ATHLETES AND PRACTITIONERS: A CRITICAL REFLECTION

MEIJEN, C.

UNIVERSITY OF KENT

Second, Meijen focuses on how 'psyching teams' deliver brief psychological interventions to runners before and during their race. These brief interventions are based on runners' strengths and use these to highlight psychological strategies that can be used during the race. Symbolic pieces of finish line ribbon, which can be attached to race bibs, are used to act as visual reminders to use the psychological strategies during the race. Many athletes use psychological skills and strategies as part of preparation and concepts such as goal-setting, self-talk, and imagery are described in both the academic and popular press. Learning psychological strategies is generally considered worthwhile as they can aid performance and improve well-being across different areas of application, people need opportunities to gain feedback. A psyching team can provide this necessary function in athlete learning without making dramatic changes on the day, as it can take a while to learn these strategies. A key part of recent work is to encourage practitioners to help athletes identify strengths and via activation of previous successful performance increase self-efficacy beliefs. We argue that the running of a psyching team offers a way for accredited practitioners to not only provide effective support to athletes, but also, help trainee sport psychologists gain experience of working in the field.

## DO ONLINE INTERVENTION VIDEOS PROVIDE A RESOURCE FOR TEACHING PSYCHOLOGICAL SKILLS?

LANE, A.M.

UNIVERSITY OF WOLVERHAMPTON

Athletes crave interventions that improve performance and help them achieve their goals. Finding an intervention that works could involve working with a professional sports scientist but recent years have seen a rapid growth in the popularity in self-help interventions. One way to learn about using a psychological skill is via youtube. Effective teaching of psychological skills, just as many skills, can be done online. In this presentation we focus on using open access videos (hosted on YouTube) which share information about how to use psychological skills and strategies, explain such skills could be used, and how the athlete might evaluate them. An online video can be used to explain what the psychological skill is, how it works, why it works, how to practice using it, and how it can be assessed. However, they have limitations when compared to working with a practitioner who can provide important contextual factors that are highly useful to effectiveness. This is analogous to a Strength and Conditioning coach demonstrating an Olympic lift, rather than helping the athlete learn the lift and then explaining where and when this technique should be integrated into training. Therefore, the practitioner should be clear that training videos represent a useful tool but that self-help methods require further work. The videos teach athletes psychological skills whether in a one-to-one session, part of a group, or via social media. These methods have considerable reach with popular videos attracting many thousands of viewers. Evaluation shows positive endorsement and an increase in belief in mental capacity to cope with the demands of endurance performance. We argue that such methods offer a practical way to deliver interventions to large audiences. Outlining concepts in an engaging way can encourage the audience to access further information and learn to use psychological strategies more effectively. It is also important for qualified practitioners to hold a presence in social media, an environment where unregulated practitioners are highly active and influential.

16:00 - 18:00

## IS-PN02 SUPPLEMENTS TO ENHANCE HYPERTROPHY AND COMBAT ATROPHY: WHAT REALLY WORKS?

### THE ROLE OF DIETARY PROTEIN IN TRAINING INDUCED HYPERTROPHY AND MUSCLE DISUSE ATROPHY: BEYOND THE USUAL SUSPECTS

WALL, B.

UNIVERSITY OF EXETER

Dietary protein is a crucial nutrient allowing the maintenance and/or reconditioning of skeletal muscle tissue. Protein ingestion, digestion and amino acid absorption provides the systemic signal, and building blocks, to stimulate the muscle anabolic machinery thereby allowing postprandial muscle protein accretion. It has been proposed that paying particular attention to the amount, type and timing of protein consumption is therefore a crucial approach to optimising muscular adaptation during prolonged resistance training regimens. This presentation will first address the current evidence supporting modern guidelines for how considerations of dietary protein intake can optimally support such training. It has also been proposed that the onset of a period of physical inactivity/muscle disuse may alter the requirements for dietary protein. Numerous data now indicate that we rapidly become less sensitive to the anabolic properties of protein when undergoing muscle disuse (i.e. the withdrawal of contraction) and this 'anabolic resistance', at least in part, may explain muscle disuse atrophy. The second goal of this talk will be to address our current understanding of the role that dietary protein intake plays in determining the extent of muscle tissue loss that occurs during a period of muscle disuse or physical inactivity.

### THE IMPACT AND MECHANISMS OF LEUCINE AND ITS METABOLIC COUSINS ON HYPERTROPHY AND ATROPHY

PHILLIPS, S.

MCMMASTER UNIVERSITY

Protein acts synergistically with resistance exercise training (RET) to stimulate muscle protein synthesis (MPS), which is a basis of muscle hypertrophy. Meta-analyses have shown that protein ingestion is both sufficient and necessary to maximize RET-induced hypertrophy. However, several lines of research have shown that the indispensable amino acid leucine is the amino acid primarily responsible for stimulating MPS. Hence, a number of studies in which leucine-enriched proteins have been fed show an enhanced stimulation of MPS over lower leucine or lower quality, as defined by various indices, proteins. The combination of all of the branched-chain amino acids (BCAA) – leucine,

isoleucine, and valine – have also been used as a combined supplement to both augment muscle anabolism and suppress catabolism. Nonetheless, the apparent effectiveness of BCAA to stimulate MPS or to enhance hypertrophy is questionable at best. The leucine metabolite  $\beta$ -hydroxy- $\beta$ -methyl butyrate (HMB) is also a popular supplement taken to ostensibly promote muscle anabolism and suppress catabolism, however, evidence for its effectiveness is limited. The aim of this presentation is to review the evidence for protein supplementation through leucine in stimulating MPS and promoting hypertrophy. Evidence for the effectiveness of BCAA and HMB will also be reviewed.

## NON-PROTEIN/AMINO ACID REGULATORS OF MUSCLE HYPERTROPHY AND FUNCTION

MITTENDORFER, B.

WASHINGTON UNIVERSITY

Amino acids stimulate muscle protein synthesis and the amino acid-induced increase in muscle protein synthesis is largely responsible for net muscle protein anabolism after meal intake. Although muscle protein synthesis after protein/amino acid intake increases in a dose dependent manner, there is an upper limit to the anabolic action of amino acid and protein intake. This makes it impossible to achieve gains in muscle mass through increased consumption of protein. Furthermore, there is little data to support a beneficial effect of increased protein intake on muscle function (strength and/or endurance). There is some evidence that non-protein/amino acid nutrients have beneficial effects on muscle protein turnover and can boost the effect of amino acids/protein on muscle protein synthesis. Some of them also improve muscle function. The aim of this presentation is to review the efficacy of non-protein regulators of muscle hypertrophy and function with special focus on n-3 polyunsaturated fatty acids.

## IS-BM02 HAMSTRING SCREENING AND ACL - (RE) INJURY PREVENTION.

### EPIDEMIOLOGY AND AETIOLOGY OF INJURIES IN COMPETITIVE ALPINE SKIERS – WHAT IS KNOWN ON THE TOPIC

STEIDL-MÜLLER, L.

UNIVERSITY OF INNSBRUCK

Alpine ski racing is a physically demanding sport with a high risk of injury independent of age and gender. At World Cup level (WCL), injury rates of 0.37 injuries/athlete were reported. More than 80% of these injuries were time loss injuries, of which more than 35% were categorized as severe injuries (time loss of > 28 days), and partly career ending. At youth levels (YL) (10-14 years), slightly higher injury rates were found (0.46-0.63 traumatic injuries/athlete) compared to the WCL, but lower incidence was reported (0.86 traumatic injuries/1000 hours of training) compared with adolescent athletes aged 16-19 years (1.7 traumatic injuries/1000 ski hours). In contrast to the WCL, most injuries at the YL (36.6%) were moderate injuries (times loss of 8-28 days), whereas at the adolescent level (AL) nearly half of the injuries were severe injuries (49%). At all levels of alpine ski racing, the knee was the most frequently injured body part by traumatic injuries (YL: 31.5-36.5%; AL: 41%; WCL: 35.6%). The most frequent diagnosis of all injuries at WCL was the rupture of the anterior cruciate ligament (ACL; 13.6%). Similarly, 13.5% of adolescent athletes sustained an ACL rupture during two seasons, whereas at the YL only 1.5-2.0% of the athletes reported an ACL rupture during the same time period. Overuse injury problems increase with age group and performance level (YL: 11.5% of athletes; AL: >50%; WCL: >1/3 of top-40 slalom athletes). At YL, anterior knee pain was the most frequently reported overuse problem, whereas at AL (36%) and WCL (34% of top-40 slalom athletes) low back pain represented the most severe overuse problem.

Prior to being able to elaborate preventive measures to reduce injury risk in alpine ski racing, injury causes have to be well understood, and preventive measures should be derived from injury risk factors, as well as injury mechanisms. Four types of injury risk factors were categorized: athlete-related, equipment-related, course-related, and snow-related injury risk factors. Among athlete-related risk factors, physical fitness seems to play a crucial role. At AL, insufficient core strength was identified as injury risk factor for ACL injuries. At YL, deficits in core strength, jump coordination and neuromuscular control, as well as asymmetries in leg extension strength were identified as injury risk factors, which might be true also for other performance levels. In this context, hamstring/quadriceps strength deficits might be relevant, as well. The multifactorial nature of injury causes in a sport like alpine ski racing with changing outdoor environment makes the elaboration of prevention measures difficult. However, findings emphasize the important role of a high level of physical fitness independent of age and performance level in the context of injury prevention in alpine ski racing.

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### HAMSTRINGS SCREENING AND ACL-INJURY PREVENTION ON THE EXAMPLE OF ALPINE SKI RACING: NOVEL PERSPECTIVES ON AN OLD STORY

SPÖRRI, J.1, FITZE, D.P.1, ELLENBERGER, L.1, FRÖHLICH, S.1, FREY, W.O.1, FRANCHI, M.V.1,2

1 BALGRIST UNIVERSITY HOSPITAL, UNIVERSITY OF ZURICH, SWITZERLAND; 2 UNIVERSITY OF PADUA, PADUA, ITALY

Hamstrings screening and ACL-injury prevention on the example of alpine ski racing: novel perspectives on an old story

Spörri, J.1, Fitze, D.P.1, Ellenberger, L.1, Fröhlich, S.1, Frey, W.O.1, Franchi, M.V.1,2

1 Balgrist University Hospital, University of Zurich, Switzerland; 2 University of Padua, Padua, Italy

Competitive alpine skiers are known to be subject to substantial risks of injury, with a rupture of the ACL being the most frequent diagnosis (1). ACL-injury mechanisms in skiing often include a boot-induced anterior drawer of the tibia relative to the femur (2). In such cases, hamstring muscles may act as an ACL-synergist by producing a posteriorly directed shear force to the tibia. Accordingly, competitive alpine skiers are typically screened with respect to their hamstrings to quadriceps (H/Q) ratio. However, in skiers such an approach has not been proven being clinically relevant yet. Additionally, it neither focuses on the rapid maximal eccentric action mode of the hamstrings that is required to resist the acting forces during the injury inciting events (2), nor any aspects of morphological muscle properties. Thus, it is time for novel perspectives on an old story. In a recent investigation, we have screened 170 competitive alpine skiers with respect to their maximal eccentric hamstrings strength (MEHS) during Nordic Hamstrings Exercise (Nordbord; Vald Performance, Australia) and provided sport-specific reference values for youth and elite skiers of both sexes (3). Moreover, in youth skiers we have found a significant positive correlation between MEHS and maturity offset ( $p < 0.001$ ), a confounding factor of MEHS testing that can be eliminated when normalising MEHS with body weight (3). In a second, extended field of view (EFOV) ultrasound-based experiment (Aixplorer Ultimate; SuperSonic

Imagine, France), we aimed to describe the biceps femoris long head morphology in 95 youth competitive alpine skiers with respect to sex, age and biological maturation. In the same cohort, a binary logistic regression analysis revealed a significant direct association between the independent variable BFLh cross sectional area (CSA; averaged between 30-60% of the femur length; [cm<sup>2</sup>]) and the occurrence of traumatic lower extremity injuries in the upcoming 12 months [yes; no] (Odds Ratio 0.709,  $p = 0.021$ ). For a preventative assessment of competitive alpine skiers, MEHS and BFLh CSA assessments may serve as two reasonably objective, reliable, and clinically relevant alternative approaches to H/Q strength.

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- 3) Franchi & Ellenberger et al., Front Physiol, 2019

**ASSESSING HAMSTRING STRENGTH DEFICITS IN ALPINE SKI RACERS WITH ANTERIOR CRUCIATE LIGAMENT INJURY**

JORDAN, M.

UNIVERSITY OF CALGARY

Alpine ski racers are at high risk for anterior cruciate ligament (ACL) injury and surgical reconstruction (ACLR) is used to restore knee joint stability (1). The semitendinosus (ST) autograft technique is often used to repair a ruptured ACL with alpine ski racers (2). But, several comorbidities arise consequent to ACLR and ST autograft, including the potential for prolonged knee flexor strength (HAMstr) deficits (3). Elite alpine ski racers with ACLR ( $n=8$ ) who had returned to skiing and were on average 2 years post-surgery demonstrated lower HAMstr compared to the non-injured limb and to skiers without ACLR ( $n=21$ ) [ACLR Limb =  $1.5 \pm 0.4$  Nm·kg<sup>-1</sup>; Non-Injured Limb =  $1.8 \pm 0.3$  Nm·kg<sup>-1</sup>; Control Group =  $1.8 \pm 0.3$  Nm·kg<sup>-1</sup>,  $P < 0.05$ ]. Additionally, knee flexor rate of torque development (rapid force production – RFD) was reduced for the ACLR limb compared to the non-injured limb [ACLR Limb =  $7.6 \pm 1.6$  Nm·s<sup>-1</sup>·kg<sup>-1</sup>; Non-Injured Limb =  $8.7 \pm 2.4$  Nm·s<sup>-1</sup>·kg<sup>-1</sup>,  $P < 0.05$ ]. HAMstr loss is also more pronounced at large angles of knee flexion ( $> 50^\circ$ ) compared to small angles of knee flexion ( $\leq 50^\circ$ ) in skiers with an ST autograft. Skiers ( $n=15$ ) who were on average 2 years post ACLR surgery with ST autograft showed a 9% side-to-side asymmetry in HAMstr at  $30^\circ$  of knee flexion compared to a 32% asymmetry at  $90^\circ$  of knee flexion [ $P < 0.01$ ]. Further, MVC normalized surface electromyography (EMG) recordings obtained from the hamstring and quadriceps muscles of elite alpine ski racers with ( $n=11$ ) and without ACLR ( $n=11$ ) during an 80s fatiguing repeated squat jump test showed altered intermuscular coordination and neural control of the hamstring muscles with fatigue and after ACL injury (4). While pre-landing (i.e. preparatory) hamstring muscle activity decreased with fatigue across all limb conditions [ $P < 0.0001$ ], it was higher with and without the presence of fatigue for the ACLR limb compared to skiers without ACLR [ $P < 0.001$ ] (4). The hamstring muscle is an ACL agonist, providing dynamic knee joint stabilization against anteriorly directed shear forces that strain the ACL (5). Hamstring muscle co-contraction appears important for knee stability during forceful knee extension, may become diminished in athletes with extensive knee extensor strength development and is trainable through targeted knee flexor strength training (6). The fact ACL injury mechanisms in alpine ski racing include positions that involve large angles of knee flexion and skiers with ACL injury are at high risk for ACL reinjury emphasize the importance of knee flexor strength training and routine knee flexor strength monitoring to restore neuromuscular function after ACLR.

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**IS-AP03 COUNTERING AGE-ASSOCIATED MUSCLE WEAKNESS: NOVEL APPROACHES AND TARGETS OF RESISTANCE TRAINING****HIGH- AND LOW-LOAD EXPLOSIVE RESISTANCE TRAINING IN ELDERLY INDIVIDUALS: ARE THERE LOAD-SPECIFIC ADAPTATIONS?**

ALEGRE, L.M.

UNIVERSIDAD DE CASTILLA-LA MANCHA

Explosive-type resistance training (RT) has been proven to be highly effective against the age-related decline in muscle power and functional ability. Recent research into the interindividual variability of training responses has underlined the necessity to tailor exercise interventions to the subjects' specific characteristics (Ramirez-Velez and Izquierdo, 2019). The selection of adequate loads (high vs. moderate or light loads) has, indeed, received increasing attention in recent years (Morton et al., 2019). Traditionally, high-load RT has been postulated to provoke superior adaptations in muscle hypertrophy and strength compared to RT performed under lower loads, and, thus, has been widely recommended for older adults (Peterson et al., 2010). However, recent evidence supports the notion that, among older people, moderate- and light-load RT may provide similar adaptations as high-load RT when prescriptions are matched by the total mechanical work performed (Csapo and Alegre, 2016). Impaired functional ability can be affected by either deficits in the high- (force) or low-load (velocity) regions of the force-velocity relationship (Alcazar et al., 2018). However, the characteristics and adaptations generated by high- vs. low-load explosive RT programmes are still understudied and there is still scarce evidence on the specific exercise intensity eliciting an optimal gain in muscle power.

We will analyse the acute and longitudinal effects of high- and low-load explosive RT programmes on muscle function in elderly people. Specifically, the adaptations in muscle size, strength, rate of force development and in the force-velocity profile of the lower limb muscles will be discussed. The presentation will provide information for the individualisation of loads for optimal adaptations, based on the individual differences in the force-velocity profiles of older adults. A better understanding of the application of RT variables will help to enhance the outcomes of training interventions oriented to improve functional ability.

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### **INTRAMUSCULAR CONNECTIVE TISSUE – TARGETING THE EXTRACELLULAR MATRIX BY RESISTANCE TRAINING**

CSAPO, R.

*UNIVERSITY FOR HEALTH SCIENCES, MEDICAL INFORMATICS AND TECHNOLOGY*

The network of intramuscular connective tissues (IMCT) constitutes the collagenous backbone of the extracellular matrix of skeletal muscles, which not only provides mechanical support to muscle fibers but also interacts with other cells, such as fibroblasts, cells of the immune system and satellite cells, in regulating muscle development, growth and repair. Functionally, the IMCT affects the contractibility of muscle fibers and serves as important medium for force transmission. Being mechanosensitive, the IMCT acutely reacts to resistance exercise by increased collagen production and degradation. However, the effects of different forms of exercise are understudied and long-term training studies are missing. Knowledge about exercise-based IMCT renewal might be of great relevance for health-oriented training, especially in elderly cohorts, in whom muscle fibrosis is common.

With the aim to stimulate increased efforts to study this still poorly understood tissue, this presentation will explain the role the IMCT plays for muscle function and summarize the current knowledge about training-induced adaptations. Novel findings from an ongoing research project investigating the effects of IMCT-specific training will also be presented. This project is run in two phases: the first (completed) tested the acute effects of four different exercise stimuli based on IMCT gene expression (COL1A1, COL7A1, MMP2, MMP3, MMP9, MMP15, TIMP1) in elderly men, to identify the form of exercise promising the greatest cell turnover; the second phase (ongoing) compares the effectiveness of 12 weeks of conventional resistance training vs. a modified training program including IMCT-specific stimuli using molecular, imaging-based and functional measures.

### **ATTENUATED EFFECTS OF RESISTANCE TRAINING IN AGED INDIVIDUALS AFTER A PERIOD OF DISUSE – THE ROLE OF MYOGENIC STEM CELLS**

SUETTA, C.

*COPENAGE - COPENHAGEN CENTER FOR CLINICAL AGE RESEARCH, UNIVERSITY OF COPENHAGEN*

The growing aging population is leading to an increasing number of older individuals recovering from shorter or longer periods of muscle disuse. Muscle atrophy not only compromises physical functioning but also is associated with increased risk of frailty and mortality. In young individuals, skeletal muscle is a highly plastic tissue, reflected in its rapid ability to adapt to changes in loading intensity. In contrast, the ability of skeletal muscle to repair and re-growth is known to diminish with aging (1,2,3).

Myogenic stem cells are one of the key regulators of muscle growth and maintenance of muscle mass (4). Notably, an impaired capacity for myogenic stem cell proliferation and activation in aged myofibers has been documented as a consequence of ageing, in mice (5) as well as human individuals (1). Systemic factors appear to play an important role in explaining part of the impaired proliferative capacity of myogenic stem cells (1). There is, however, also evidence of local mechanisms influencing stem cell activation (6) as well as data suggesting a close relation between various systemic and local factors in the regulation of myogenic stem cells function in vivo (7). In summary, there is a delayed response in aged individuals to recover from atrophy which has important implications for the development of effective rehabilitative countermeasures against physical frailty in the continuously growing population of elderly adults.

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### **IS-SH06 OPTIMIZING ELITE ATHLETES DUAL CAREER PATHWAYS IN EUROPE**

#### **GOLD IN EDUCATION AND ELITE SPORT: WHICH COMPETENCIES DO ATHLETES AND PRACTITIONERS REQUIRE TO OPTIMIZE THE DUAL 'EDUCATION AND ELITE SPORT' PATHWAY?**

DE-BRANDT, K., WYLLEMAN, P., DEFROYT, S.

*VRIJE UNIVERSITEIT BRUSSEL*

One of the main challenges athletes face is combining elite sport with other pursuits such as education and/or work. As this dual career (DC) pathway spans the development and mastery stages of an athletic career, it significantly impacts athletes' educational, athletic and vocational development during as well as after their athletic career. Taking into account the many potential benefits of athletes' engagement in a DC (e.g. increased chances of employability, development of multiple identities, reduced life stress, positive socialization effects, prolonged athletic careers), European sport, research and policy has attached increasing importance to athletes' DC. This first of three presentations on 'Optimizing elite athletes' dual career pathways in Europe' will highlight the findings of the 'Gold in Education and Elite Sport' (GEES) project, initiated in 2015 with the support of the Erasmus+ programme of the European Union. Coordinated by the Vrije Universiteit Brussel and INSEP (France), the project brought together a consortium of 40 internationally renowned dual career (DC) researchers and expert practitioners from 17 research centres and elite sport organisations from nine EU Member States (Belgium, France, Italy, Netherlands, Poland, Slovenia, Spain, Sweden, UK).

GEES provided data on (1) athletes' competencies to successfully manage their DC 'education and sport' pathway, (2) DC support providers' competencies to support athletes during their DC pathway, and (3) instruments and methods to assess and develop the quality of DC

services. The presentation's specific objectives are to introduce the Dual Career Competency Questionnaire for Athletes (DCCQ-A; De Brandt et al., 2018) and Support Providers (DCCQ-SP; Defruyt et al., 2019) in order to (1) explain how student-athletes' and DC support providers' competencies are evaluated, (2) highlight the main findings obtained with the DCCQ-A and DCCQ-SP in 3,500 European student-athletes and 330 DC support providers, and (3) provide examples of how the (results of the) DCCQ-A and DCCQ-SP can be used in practice. The results of GEES are valorised in a handbook for DC support providers and an online evidence-based platform ([www.dualcareertools.com](http://www.dualcareertools.com)). GEES continues to raise awareness across Europe on the importance of developing athletes' and DC support providers' competencies.

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### **BE A WINNER IN ELITE SPORT AND EMPLOYMENT BEFORE AND AFTER ATHLETIC RETIREMENT: HOW CAN WE OPTIMIZE ATHLETES' EMPLOYABILITY?**

VITALI, F., TABARINI, N., SCHENA, F.

UNIVERSITY OF VERONA

#### **Introduction**

Enhancing the employability after sport retirement is a key challenge for elite athletes. Taking into account the lack of empirical data regarding the employability of active and former elite athletes, a consortium of universities and elite sport centres from six EU Member States (i.e., Belgium, Germany, Italy, Slovenia, Spain and Sweden) initiated the project 'Be a Winner In elite Sport and Employment before and after athletic Retirement' (B-WISER). B-WISER was launched in 2017 with the support of the Erasmus+ EU Sport programme. B-WISER aimed at optimizing the employability of elite athletes in three career stages: (1) when active (D), (2) when retired and preparing for a first-time employment (R), and (3) when employed in their post-athletic career (P). In this context, the aims and findings of the first three work packages (WPs) of B-WISER will be presented.

#### **Methods**

WP1 identified the roles and contributions of 169 stakeholders who provided support to (former) elite athletes regarding their employability through an online survey. WP2 analysed the competencies developed by 954 elite athletes in the three career stages (D, R, P) using the Athletes' Competency Questionnaire for Employability. Finally, in WP3 65 employers were interviewed in focus groups and face-to-face interviews about the reasons why they (do not) hire athletes.

#### **Results**

Around 80% of the 169 stakeholders stressed the need for specific support for (former) elite athletes in the workplace or in preparation for employment. Individual (43%) and group counselling (7%), as well as support-in-job placement (21%), were evaluated as the main coaching practices. The greatest barriers to optimize athletes' employability included time constraints and lack of long-term perspective. Participants involved in WP2 reported average-to-strong possession of their competencies (M=3.77). Former elite athletes who were employed (P) perceived the strongest possession of their competencies (M=3.90). Overall, participants reported the weakest possession for the ability to create a professional network, to identify themselves with the culture of their organisation, and the understanding of their own career interests and options. Finally, in WP3 employers perceived affinity with sports, increased cooperation with sports organisations, strong competencies (e.g., goal-orientation, dedication and self-discipline), and commercial purposes as main reasons to hire (former) athletes. The need for flexibility, lack of transferable key competencies, and occupational delay were perceived as reasons to not hire (former) athletes.

#### **Discussion and Conclusion**

The findings can be used as an evidence base for stakeholders (e.g., career counselors, employers, sport federations, educational institutions) to target specific interventions. They serve as a basis to develop methods aimed at promoting the added value of employing active and former elite athletes for the world of sport, education and employment.

### **THE DEVELOPMENT AND IMPLEMENTATION OF EDUCATIONAL MODULES FOR DUAL CAREER SUPPORT PROVIDERS: A EUROPEAN PILOT**

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1UNIVERSITAT AUTÒNOMA DE BARCELONA, 2CENTRE DALT RENDIMENT DE SANT CUGAT DEL VALLÈS

#### **Introduction**

Previous European projects in the field of dual career (DC) such as "Gold in education and elite sport (GEES)" and "Be a winner in elite sport and employment before and after athletic retirement (B-WISER)" identified a need for the continued professional development of those individuals supporting student-athletes, i.e. the dual career support providers (DCSP). Therefore, the IOC project entitled "The development and evaluation of training modules for DCSPs: a European pilot\*" was initiated in 2017 and aimed at developing, implementing and evaluating specific training modules for DCSPs. These modules included: (a) the discussion of ethical principles, and (b) the self-awareness and development of their own competencies.

#### **Methods**

Evidence-based contents for the modules were generated through focus groups with 11 international DC experts. Modules were implemented in four countries (i.e., Belgium, Netherlands, Sweden, Spain) in 4-hour workshops. This presentation outlines the implementation of the modules in Spain, provided by two experienced DCSPs to 15 participants (ranging from novice to expert DCSPs). The module 'Ethical Principles' discussed ethical behaviours, morally conflicting cases, and ethical thinking in DCSPs' practice. In the second module 'Development of competencies', DCSPs answered a questionnaire aimed at self-evaluating their own competencies, discussed the roles and responsibilities of DCSPs, and created a professional development plan.

#### **Results**

Both workshop providers and participants evaluated the modules through a survey and/or interview. In general, the modules were positively evaluated, especially in terms of content, duration, productivity, and autonomy supportive climate. The main strengths were the sensitivity to balance theoretical content and practical exercises in a reflective but relaxed atmosphere. As a potential improvement, the

participants recommended splitting the training modules into two days in order to increase the time for reflection and practical exercises. In addition, they suggested including content with regard to gender differences, adding more cases with ethical dilemmas (e.g., conflicts of interest, confidentiality) and offering homework before and after the modules to encourage deeper reflection. In a follow-up interview, 10 participants reported they had implemented the knowledge acquired in the modules.

**Discussion**

The findings highlight the importance of this type of training modules for DCSPs' professional development. The modules provide persons with this specific job profile the opportunity to share experiences with other DCSPs of different levels of experience. The development, implementation and evaluation of these modules are an important first step in the provision of specific training for DCSPs and lead the way to establish the DCSP job profile across Europe.

\*This research is funded by the Advanced Olympic Research Grant Programme of the IOC Olympic Studies Centre.

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## Live Sessions: Friday, October 30, 2020

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08:00 - 10:00

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### IS-PN07 HYDRATION AND HEAT STRESS RESPONSE - PHYSIOLOGICAL ADJUSTMENTS AND ADAPTATIONS

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#### HEAT STRESS EXERCISE, HYDRATION AND THE ADJUSTMENTS OF THE HUMAN BRAIN, HEART AND MUSCLES

GONZÁLEZ-ALONSO, J.

*BRUNEL UNIVERSITY LONDON*

People undertaking prolonged vigorous exercise experience substantial bodily fluid losses due to thermoregulatory sweating. If these fluid losses are not replaced, endurance capacity may be impaired in association with a myriad of alterations in physiological function, including hyperthermia, hyperventilation, cardiovascular strain with reductions in brain, skeletal muscle, skin and possibly visceral blood perfusion, greater reliance on muscle glycogen and cellular metabolism, alterations in neural activity and, in some conditions, compromised locomotor muscle metabolism and aerobic capacity. Progressive dehydration is also associated with an accelerated drop in perfusion and oxygen supply to the human brain during submaximal and maximal aerobic exercise. Yet their consequences on aerobic metabolism are greater in the exercising muscles because of the much smaller functional oxygen extraction reserve. The physiological strain accompanying progressive exercise-induced dehydration can be attenuated or even prevented by (1) ingesting fluids during exercise, (2) exercising in cold environments, and/or (3) working at intensities that require a small fraction of the overall body functional capacity. In this talk, speaker 1 will highlight how dehydration differentially impacts physiological function during competitive exercise requiring high functional demand with an emphasis on the adjustments of the human brain, heart, and muscles and their consequences on endurance performance.

#### DOES DEHYDRATION ENHANCE HEAT TRAINING ADAPTATIONS?

PÉRIARD, J.

*UNIVERSITY OF CANBERRA*

Heat acclimation is known to induce adaptations that improve submaximal exercise performance, maximal aerobic capacity, and perceptual responses in the heat. These benefits are achieved through enhanced sweating and skin blood flow responses, plasma volume expansion, better fluid balance (i.e. total body water maintenance) and cardiovascular stability, as well as acquired thermal tolerance. The expansion of plasma volume in particular, is highly dependent on the intravascular and oncotic pressures related to exercise intensity and hydration status. As such, permissive dehydration during repeated exposures to exercise-heat stress may facilitate the adaptation process by increasing fluid-electrolyte retention, leading to plasma volume expansion and enhancing cardiovascular responses to heat stress. Conversely, dehydration may override or negate the adaptive effects related to the heat acclimation phenotype via chronic reductions in total body water. This presentation will examine the evidence regarding the role of permissive dehydration during heat acclimation on the induction of cardiovascular and thermoregulatory adaptations (i.e. time course and magnitude). The adaptations will be placed in the context of improving exercise performance in hot, as well as cool conditions.

#### NEW THOUGHTS ON DEHYDRATION, ADAPTATION AND PERFORMANCE: HOW SHOULD ATHLETES ADDRESS FLUID NEEDS DURING SPORT?

BURKE, L.

*AUSTRALIAN INSTITUTE OF SPORT*

Early research on the effect of dehydration on performance concluded that a fluid deficit above a threshold equivalent to ~2% BM was sufficient to impair performance, particularly in hot conditions. However, there have been recent challenges to this notion. Issues speaking to the overestimation of the effect of dehydration include the failure of laboratory based studies to account for real world conditions or the “placebo” effect of drinking, as well as the observation that many athletes incur substantial fluid deficits during “winning” performances. On the other hand, the small margins between winning and losing, the effect of dehydration on the “mental cost” of performance in events requiring repeated efforts, and the central nervous system benefits associated with oral sensation of fluid intake or cooling provide an incentive for a proactive fluid plan. Novel research protocols are attempting to remove some of these previous biases in their investigation of the effects of dehydration on sports performance, while other investigations are comparing “planned drinking” versus “drinking to thirst” as the underpinning theme of fluid practices. Whether repeated exposure to exercising in a dehydrated state “trains the body” to tolerate a fluid deficit or leads to a reduction in training quality and adaptation is a relevant question for athletes who are deliberately preparing for hot weather competition.

## Invited symposia

### **IS-AP07 INTEGRATING DATA SCIENCE AND MONITORING TO IMPROVE ATHLETES PERFORMANCE AND HEALTH**

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#### **CONTINUOUS MONITORING OF ATHLETE PERFORMANCE AND HEALTH IS WORTH IT - EVEN THOUGH IT DOES NOT COME CHEAP NOR EASY**

VERHAGEN, E.

*VU UNIVERSITY MEDICAL CENTER*

When it concerns performance enhancement a lot of funds and effort are being put in - amongst others - the development of new training methods, training materials, and equipment. All with the aim to make our athletes stronger, faster and better. What is generally neglected is that in order for athletes to (fully) benefit from newly developed and improved training methods they have to remain in full health. Developments in the continuous registration of injuries have shown that injuries are a constant and performance limiting problem in sports, and it has become apparent that athletes compete while injured. This results in inefficient training and suboptimal performance. This presentation outlines an integrated approach towards healthy and optimal performance, which integrates independent components on load, load capacity, performance and health. Via data science and machine learning approaches, the strength and temporality between these components can be assessed. Such continuous and prospective monitoring is the cornerstone of performance while it is able to manage the risk of adverse effects and inefficient loading in near-real time. This presentation will illustrate with practical and scientific examples the value of such intense monitoring in recreational sports, professional sports, as well as performing arts.

#### **HOW IS ATHLETE MONITORING BEING USED TO OPTIMISE PERFORMANCE AND REDUCE INJURY RISK IN HIGH-LEVEL TEAM SPORTS?**

Without abstract submission

#### **MONITORING THE HEALTH OF ATHLETES AND DANCERS: FACTORS INFLUENCING IMPLEMENTATION**

STUBBE, J.

*CODARTS ROTTERDAM*

Athletes and dancers have at least two things in common: they have to perform well in high-pressure situations and face challenging physical demands. There is barely any time to recover, which makes athletes and dancers prone to injuries due to overload. Self-report measures such as questionnaires and diaries are suggested to be a simple and cost-effective approach to monitor an athlete's and dancers response to training, however their efficacy is dependent on how they are implemented and used.

Codarts Rotterdam has developed the Performing artist and Athletes Health Monitor (PAHM) to monitor the health of athletes and dancers. Over 1,000 athletes and performing artists use this monitor, including soccer players from the Dutch Premier League club Feyenoord and dancers from the Dutch National Ballet. Dr. Janine Stubbe will share her experiences with large scale injury data collection across both sport and dance. She will focus on the development, implementation and evaluation of her online tool for monitoring the physical and mental health of athletes and dancers. She will discuss some of the factors influencing response rate and the implementation of health monitoring tools. To close, Janine will present the lessons learned from more than 10 years of health data collection in sports and dance.

### **IS-AP06 PACING AND COACHING: HOW CAN COACHES DEVELOP PACING SKILLS IN THEIR ATHLETES?**

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#### **TIME PERCEPTION AND OTHER UNDERLYING SKILLS REQUIRED FOR OPTIMAL PACING: WHAT ARE THE IMPLICATIONS FOR COACHING?**

EDWARDS, A.

*CANTERBURY CHRIST CHURCH UNIVERSITY*

It is known that perception of time (subjective time) is manipulable and distortable under certain circumstances. It has previously been shown that during dangerous incidents events appear to pass in slow motion as if time has slowed down and this effect has also recently been demonstrated in high vs low intensity exercise. In practical terms this means that as exercise intensity increases, the subjective perception of time elapsed decreases (shrinks) due to greater than usual sensory awareness in a given period of time; hence measured (chronological) time runs slower than subjective time, giving the impression that 'real-time' has slowed down. Distortions to the perception of time can be problematic to coaches and athletes in optimally executing a race plan, but this also potentially presents opportunities to manipulate training parameters so to achieve greater performance outcomes. This presentation will identify and discuss current research in this area, implications and practical applications for coaching in sports across different population groups.

#### **PACING AND SELF-REGULATION IN YOUTH ATHLETES: HOW TO COACH YOUTH ENDURANCE ATHLETES TOWARDS EXCELLENCE?**

ELFERINK-GEMSER, M.T., HETTINGA, F.J., MENTING, S.G.P.

*UNIVERSITY OF GRONINGEN, UMCG, NORTHUMBRIA UNIVERSITY*

Youth endurance athletes aiming to reach the elite level in their sport need to develop multiple underlying personal performance characteristics such as pacing in order to succeed (1). Pacing has been characterized as a multi-faceted goal-directed process of decision-making

in which athletes need to decide how and when to invest their energy during the race (2). The developmental process towards elite sports entails many years throughout adolescence. Both physiological as well as psychological characteristics associated with adequate pacing and performance are known to develop with age. Consequently, the multi-faceted skill of pacing seems under construction throughout adolescence as well, influencing performance. This is supported by studies in talented speed skaters, in which better performing adolescent skaters developed more towards an elite adult pacing profile than their less performing counterparts (3,4). By applying the cyclical process of self-regulation to pacing, we propose a practical model for the development of performance in endurance sports in youth athletes (5). Self-regulation is a goal-driven process consisting of metacognition, motivation, and behavior (6). Successful youth athletes are characterized by their high scores on self-regulation (7). Athletes who are skilled at self-regulation score high on reflection, they plan their performance in advance, monitor whether they are still on track during the actual performance, and evaluate their performance afterwards. This is exactly what is needed for developing a pacing template.

Conform literature on self-regulation and pacing, prior experiences are highly relevant in the proposed model. Information from prior races is used as input for the next race, to anticipate on the exercise demand and divide the available energy optimally. Based on increasing experience with the task, athletes build a 'performance template' (8). To help athletes in building their performance template, trainers can provide feedback on split times during training sessions on a regular basis, and if possible, also during and after races. It is hypothesized that in this way athletes can learn to couple bodily sensations (e.g., perceived exertion, heart rate frequency, breath frequency, fatigue, and pain) to their performance. The three phases that have been proposed in pacing literature from a meta-cognitive perspective (i.e., preceding the race, during the race, and after the race) as well as the forethought, performance, and self-reflection phase from self-regulation literature, are central to our proposed model for development of pacing skills in youth athletes (5). Coaches and trainers are advised to incorporate pacing as a performance characteristic in their talent development programs by stimulating their athletes to reflect, plan, monitor and evaluate their races on a regular basis to build performance templates and as such, improve their performance.

### **PACING AND PERFORMANCE IN INTELLECTUALLY IMPAIRED ATHLETES: THE ROLE OF COGNITION IN PACING**

VAN-BIESEN, D.

*LEUVEN UNIVERSITY*

An essential determinant for success in sports is pacing. Cognitive mechanisms like self-regulation and executive functions are strongly related to adequate pacing behaviour, and people with Intellectual Impairment (II) experience shortfalls in those skills. Previous literature in children without II revealed that pacing is at least partly dependent on cognitive development. Research that focuses on pacing abilities of individuals with II strengthens the assumption that intellectual functioning is involved in pacing, as elite athletes with II are not able to maintain a pre-planned submaximal velocity and they regulate their exercise intensity differently compared to athletes without II. During this presentation, the role of cognition in pacing will be highlighted, along with insights generated through the previous and current research into the impact of II on pacing behaviour. The importance of pacing within the development and optimization of evidence-based classification systems for athletes with II in the Paralympic Games across sports will be discussed by means of examples in athletics, swimming, Nordic Ski and team sports.

### **IS-MH01 EXERCISE AND HEALTHY AGEING: NEUROMUSCULAR CAPACITY AND VASCULAR AGEING**

#### **TRADITIONAL AND RECENT TRAINING CONCEPTS TO IMPROVE NEUROMUSCULAR PERFORMANCE WITHIN ACTIVE AGING**

DONATH, L.

*GERMAN SPORT UNIVERSITY*

Beside aging-induced cardiovascular deteriorations, neuromuscular impairments lead to increasingly elevated fall rates in elderly people. One out of three seniors above 65 years of age fall once a year. Balance training attenuates declines of neuromuscular capacity and reduces fall rates by 21%. A Reduction up to 50% can be achieved when exercises provides a challenging stimuli to balance over 3 weekly training hours. Thus, intrinsic fall risk factors (e.g., static, reactive, dynamic and functional balance) benefit in dose-response relationship from fall preventive exercise training. Recent training studies and meta-analyses emphasized that adaptations to balance training seem to be highly task-specific. Transfer effects to non-trained neuromuscular tasks are limited. Thus, the present talk draws a bow from mechanistic considerations of neuromuscular adaptations to neuromuscular training over traditional and non-traditional fall-preventive exercise training programs to evidence-based best-practice recommendations. This lecture underlines the importance of the "task-specificity principle" for balance training programming based on high level of scientific evidence. Secondly, several appealing exercise training approaches on fall risk factors will be discussed in the light of agility training, fall training and instable exergaming. We will further elaborate how these aspects can track into general exercise-based fall prevention recommendations. The talk might be relevant for a broad audience interested in recent findings on mechanistic considerations of balance training adaptations and exercise-based and health-related fall prevention recommendations in older people from a practitioners' and researchers' perspective.

#### **EXERCISE AND VASCULAR AGEING**

HANSEN, H.

*UNIVERSITY OF BASEL*

Cardiovascular disease is a main determinant of morbidity and mortality in western countries and age is a key risk factor for its development. Older age coincides with a high prevalence of obesity and low levels of physical activity. Ageing is associated with complex structural and functional alterations of the macro- and microvascular bed, but the vascular mechanisms of ageing and its association with physical activity are unknown. An impairment of the buffer capacity of large arteries and the progression of arterial stiffness may lead to elevated left ventricular afterload and left ventricular hypertrophy and, at later stages, heart failure, increased risk of stroke and dementia due to damaging of the microcirculation. Retinal vessel analysis (RVA) is a non-invasive technique that allows the examination of the cerebrovascular bed, which is affected early in the process of arteriosclerosis. In recent years we have developed and applied vascular biomarkers such as RVA to help define vascular end organ damage more specifically. The presentation gives insights into the association of large and

small artery function with physical fitness and activity in young children as well as older adults. We aim to demonstrate the importance of specific physical activity programmes to achieve healthier ageing as a long-term goal. Exercise-related improvement of vascular function represents the potential to counteract vascular ageing during lifespan.

### **METABOLIC CROSSTALK BETWEEN THE ENDOTHELIUM AND MACROPHAGES IN MUSCLE**

DE-BOCK, K.

*TECHNICAL UNIVERSITY OF ZURICH*

Angiogenesis, the formation of new blood vessels from existing ones, is initiated by the secretion of growth factors – the vascular endothelial growth factor VEGF is the best described one - from a hypoxic environment. To grow under low oxygen conditions, ECs have unique metabolic characteristics. Indeed, even though they are located next to the blood stream - and therefore have access to the highest oxygen levels - ECs are highly glycolytic. However, when they need to sprout into avascular areas and form new vessels, they upregulate glycolysis even further to fuel migration and proliferation. Suppression of glycolysis via inhibition of the glycolytic regulator PFKFB3 (phosphofructokinase-2/fructose-2,6-bisphosphatase isoform 3) in endothelial cells prevents blood vessel growth in the retina of the mouse pup and also in various models of pathological angiogenesis. While we now know that ECs are metabolically preconditioned to rapidly form new vessels, it remains an outstanding question whether this also holds true in muscle and whether endothelial metabolism can become a target for the treatment of age-related diseases such as peripheral artery disease.

We recently could show that EC specific loss of PFKFB3 reduced revascularization of the mouse ischemic hindlimb and impaired muscle regeneration. This was caused by the reduced ability of macrophages to adopt a proangiogenic and proregenerative phenotype. Mechanistically, we found that endothelial cells metabolically communicate with macrophages to drive M2-like polarization of macrophages during recovery from ischemia. In summary, we have identified angiocrine metabolic properties of ECs during muscle regeneration from ischemia.

## **IS-PN01 COGNITIVE FUNCTION IN RESPONSE TO PHYSIOLOGICAL AND PSYCHOLOGICAL STRESSORS AND ENVIRONMENTAL CHALLENGE**

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### **EFFECTS OF ACUTE EXERCISE AND HYPOXIA ON COGNITIVE PERFORMANCE**

ANDO, S.

*UNIVERSITY OF ELECTRO-COMMUNICATIONS*

Cognitive function refers to processes such as memory, attention, language, and problem solving and planning. Given that many cognitive processes involve sophisticated functions specific to humans, cognitive performance plays an important role in our daily activities, including sports. Hence, considerable attention has been devoted to how acute exercise alters cognitive performance. It has been suggested that acute exercise at moderate intensity has beneficial effects on cognitive performance. Hence, in the first part, I will discuss how acute exercise improves cognitive performance, together with recent neuroimaging evidence. In contrast to the beneficial effects of acute exercise, hypoxia seems to have the detrimental effects on cognitive performance. So, question arises how cognitive performance is altered when acute exercise was combined with exposure to hypoxia. In the second part, I propose that the combined effects of hypoxia and exercise on cognitive performance are determined by interactions among the severity of hypoxia, duration of exposure to hypoxia, cognitive domain, and exercise intensity and duration. I will discuss the physiological mechanism(s) of interaction and suggests that alterations in neurotransmitter function, cerebral blood flow, and possibly cerebral metabolism are the primary candidates that determine this physiological interaction. The present study has implications for sporting, occupational, and recreational activities at high altitude.

### **CEREBRAL METABOLISM AND EXECUTIVE FUNCTION FOLLOWING EXERCISE**

HASHIMOTO, T.

*RITSUMEIKAN UNIVERSITY*

Executive function (EF) relates to working memory, reasoning, task flexibility, and problem solving. EF is an overall function of many brain sites such as the dorsolateral prefrontal, anterior cingulate, and parietal cortex and can be evaluated by use of the Stroop task. Cognitive function as evaluated by the Stroop task is enhanced following prolonged exercise, despite hyperventilation-induced decrease in cerebral blood flow, suggesting that exercise-enhanced cognitive function relates to augmented cerebral neuronal activity and metabolism, rather than cerebral perfusion. Although the brain relies mainly on glucose at rest, the cerebral consumption of glucose decreases during intense exercise, along with an increase in blood lactate of consequence for the cerebral uptake. Both cognitive tasks and exercise increase neuronal activity and energy demand, and, high volume exercise with sufficient intensity, that produces lactate, prolongs the exercise-enhanced EF. Here, I propose the hypothesis that peripheral (mainly muscle) lactate production affects brain lactate uptake (i.e., differences across the brain for lactate) and metabolism after exercise, and that changed brain lactate uptake after exercise may relate to ability to maintain exercise-enhanced brain function as assessed by EF. I also discuss other possible factors to affect EF in response to exercise such as brain-derived neurotrophic factor.

## IS-PN06 HYPOXIC EXERCISE: PERFORMANCE AND HEALTH BENEFITS

### MUSCLE POWER AND STRENGTH TRAINING UNDER HYPOXIC CONDITIONS

FERICHE, B.

GRANADA UNIVERSITY

The combination of the systemic hypoxia and resistance training has become a topic of research of great interest in the last decade. Compared to normoxia, resistance training conducted under hypoxic conditions is associated with enhancement of the exercise-induced metabolic stress mechanisms, which clearly have an important role in hypertrophy and muscle strength. Additionally, improvements in explosive movements such as throwing and jumping have been observed at altitude. The direct effect of hypoxemia on the supraspinal structures, the increase in the anaerobic metabolism and/or the reduced aerodynamic resistance can influence motor unit recruitment patterns and may be responsible for these improvements. Consequently, a hypoxic environment appears to create advantageous responses in the development of muscle performance by increasing hypertrophy and gains in both muscle strength and velocity of explosive movements. Moreover, the effect that these changes could have on the space-time pattern of sports technique should also be considered for study. Based on the current knowledge on strength/hypertrophy and power development in whatever type of hypoxia, as well as the different factors that could influence the analyzed topic it could be stated that: 1) natural moderate hypoxia, not simulated, seems to improve the force-velocity relationship from immediately after the ascent and induce faster and higher enhancements in muscle power capacity after an oriented training period; 2) altitude ascent interferes with the effectiveness of complex movements requiring a technique restoring period at altitude and after the descent; 3) large discrepancies in the training protocols among studies do not allow to clearly state gains in muscle size in response to resistance training under hypoxia conditions. More specific controlled studies are needed to clarify the potential role that the natural and simulated hypoxia could play in whatever resistance training purpose.

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### NON-HAEMATOLOGICAL ADAPTATIONS TO ALTITUDE TRAINING

USAJ, A.

UNIVERSITY OF LJUBLJANA, FACULTY OF SPORT

Studies assessing performance improvements after training at altitude have produced ambiguous results. Instead of haematological adaptations as a consequence of hypoxic dose (HD), also non-haematological adaptations occur as a result of training hypoxic dose (THD) and training dose (TD), by using living-high and training-low (LHTL) altitude training. The non-haematological adaptations can be observed through enhancements in respiratory, cardiovascular and muscular function. However, their influence may be masked or modified by simultaneous effect of haematological adaptations. Recognizing their specific influence on performance seems to be relevant topic, which may help in understanding of adaptations during altitude training and in improving the LHTL method. Therefore, during the oral presentation the results obtained in our research will be showed. We have studied the non-haematological adaptations by avoiding significant haematological alterations, using reduced HD at unchanged THD and HD. Even in an absent of haematological adaptations endurance performance was enhanced more by using LHTL with reduced HD in comparison to the similar sea-level training. Different pathways of adaptations were found. LHTL with reduced HD decreased ventilation, carbon dioxide production (Vco2) and increased muscle oxygenation. Blood lactate concentration and Vco2 decreased during sea-level training. Differences in non-haematological adaptations partially explain differences in performance.

### HYPOXIC EXERCISE AND HEALTH BENEFITS

TIMON, R.

SPORT SCIENCES FACULTY. UNIVERSITY OF EXTREMADURA

It is established that exercise combined with hypoxia causes specific responses, not observed when the same exercise is performed in normoxia. Performing exercise in hypoxic conditions can induce muscular adaptations, improve the oxygen transport capacity and increase the physical performance. Although the hypoxic exercise has been more common in the field of sports performance, it could have also positive effects on health. Chronic hypoxia exposure may increase systemic inflammation and produce negative effects on people's health, but paradoxically, exposure to intermittent moderate hypoxia may improve metabolic risk factors and bone mineral density in obese and elderly people. Most of these changes are modulated by the hypoxia-inducible factor 1 $\alpha$  that acts on many cell groups due to decreases in available oxygen. According to results obtained in our laboratory, high-intensity interval training under normobaric intermittent hypoxia in obese women seems reduce body fat and increase the energy expenditure. Additionally, the hypoxic exercise in elderly people has reduced the loss of muscle mass and improved the quality of life of the elderly. During the oral presentation, a review of the current studies related to this topic will be made and the results obtained by the research group of the speaker will be showed. In conclusion, it will be stated that this novel strategy of exercising in normobaric hypoxia may be useful for clinical applications in different populations.

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## IS-AP04 HOW TO MOVE WITHOUT MOVING: NON-PHYSICAL APPROACHES OF TRAINING, APPLICATIONS FOR REHABILITATION AND NEURAL MECHANISMS

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### MOVE WITHOUT MOVING: NEURAL CORRELATES OF STRENGTH INCREASE AFTER MENTAL TRAINING

GROSPRETRE, S.

*C3S - EA4660*

Introduction: It is now admitted that training by Motor Imagery (MI), i.e. the internal simulation of movement without corresponding motor output, leads to a significant enhancement of motor performances and more particularly muscle strength. To date, this increase in performance following MI training without any specific physical activity was attributed to cerebral plasticity only. Indeed, it is well known that MI and actual movement production activate similar cortical areas mostly devoted to motor control, such as prefrontal, parietal, supplementary, premotor and primary motor cortices. However, several evidences emerged in the last decade that MI also generates a minor cortical output that can reach the spinal network. More specifically, it was shown that the presynaptic interneuronal network that mediates the spinal reflex pathway is particularly involved when participants mentally simulate an action. As a consequence, MI may induce several acute and chronic adaptations in a wider range of the neural pathway than expected, from the brain to the muscle. This is of particular interest since changes in spinal excitability for instance are considered as a key component of muscle strength increase after training. Based on recent findings, the aim of this talk is to summarize the neural changes from the brain to the spinal cord that allow an enhancement of strength after MI training in healthy participants, and to propose practical recommendation to maximize this neural plasticity.

### MOVE WITHOUT MOVING: ENHANCED FUNCTIONAL PERFORMANCE AFTER BOUTS OF COGNITIVE TRAINING

MARUSIC, U.

*SCIENCE AND RESEARCH CENTRE KOPER*

In addition to physical training, different forms of non-physical training have been shown to positively influence motor performance and motor learning also in the older age. A recent sports medicine review recognizes non-physical exercises in the early phases of rehabilitation and highlights injury-related reorganization of the central nervous system that might cause alternations in neural networks, somatosensory dysfunction and motor system excitability (Needle et al., 2017). New approaches developed from an underlying brain-based model therefore seek to find better ways to effectively train and (re-)learn motor programs when physical exercise is limited or even not possible. This talk will introduce different forms of mental training such as (computerized) cognitive training, motor imagery, and movement observation during periods of prolonged physical inactivity. Recent studies have demonstrated that cognitive training alone can lead to improved mobility performance in different populations (e.g. healthy elderly or patients with Parkinson's disease) due to a close link between enhanced cognition and motor control. To illustrate this close link, the talk will present the current behavioral adaptations in gait control, neural adaptations of the brain assessed by existing neuroimaging technology, and biomarkers assessed through blood samples.

### MOVE WITHOUT MOVING: THE USE OF NON-INVASIVE BRAIN STIMULATION AS A TRAINING TOOL

PERREY, S.

*UNIV. MONTPELLIER*

Transcranial direct current stimulation (tDCS) is a neuromodulation technique that has received increasing attention due to its potential impact on brain activity in healthy subjects as well as patient populations. TDCS is a non-invasive, portable, easy to use, safe, well-tolerated, in which a weak electric direct current is applied to the scalp with the intention to modulate cortical excitability and plasticity as well as influence behavior. Modulation can be explained mainly by synaptic reinforcement (long term potentiation) or by changes at neuronal excitatory thresholds. Over the past decades numerous studies showed the positive effects of tDCS on cognitive function and motor performances in patients with various kinds of diseases. The amount of studies on the effects of tDCS on motor performances of healthy or active participants is still low and most of them focused on the acute effects of one single session with some discrepancies among the current findings from the literature. Rather, this talk will focus on some recent evidences dealing with the use of various promising tDCS protocols during multiple sessions on motor and cognitive performances.

## IS-MH04 EXERCISE ONCOLOGY: LOOKING INTO MOLECULAR MECHANISMS, INDIVIDUALIZATION OF EXERCISE RECOMMENDATIONS AND HOW TO USE BEHAVIOR STRATEGIES TO FACILITATE EXERCISE

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### BENEFITS OF EXERCISE DURING CANCER MANAGEMENT - WHAT COUNTS MOST, EXERCISE FREQUENCY, INTENSITY, DURATION, MODE OR IS IT ONLY A MATTER OF TOTAL AMOUNT OF PHYSICAL ACTIVITY?

BERNTSEN, S.

*UNIVERSITY OF AGDER*

The knowledge within exercise oncology has enhanced rapidly, and today cancer patients and survivors are recommended to avoid inactivity and return to normal daily activities as soon as possible following diagnosis. Further to engage in regular physical activity at moderate- or vigorous intensity, in addition to include strength training exercises. However, the current recommendations are generic, and a one-size fits all approach that do not take into account individual characteristics like age and fitness-level, type of cancer and disease trajectory as well as treatment side-effects. In this talk we argue that individualized physical activity recommendations addressing exercise frequency, intensity, duration and modes of exercise are needed. We will provide insights in and an updated overview of studies comparing different exercise modes, frequency, intensity and duration for specific outcomes. In addition, we will point out knowledge gaps that needs to be addressed in future research. The target audiences are all interested in exercise during cancer management.

**MUSCULAR RESPONSES TO SYSTEMIC THERAPIES AND EXERCISE IN CANCER PATIENTS**

RAASTAD, T.

NORWEGIAN SCHOOL OF SPORT SCIENCES

It is well known that different types of systemic cancer therapy (e.g. chemotherapy and hormone therapy) have detrimental effects on healthy tissues besides the therapeutic effect on tumors. Negative effects of anthracyclines on cardiac tissue is the most studied side effect on muscle tissues, but emerging evidence suggest that anthracyclines and other widely used systemic therapies have significant negative effects on skeletal muscles as well. It has been shown in animals (1,2) and in recent human studies, that muscle size, force generating capacity, and mitochondrial structure and function are negatively affected by chemotherapeutic agents and hormone therapy (3,4,5). Detrimental effects of systemic therapies on skeletal muscle can be long lasting and may affect muscle function several years after end of treatment. Consequently, muscle related alterations due to systemic therapies have been suggested to contribute to long lasting cancer related fatigue and effective strategies to prevent these side effects are of great importance. Optimal doses of exercise during systemic therapy could be an effective strategy to counteract some of the detrimental effects on muscle. Results from small scale human studies indicate that exercise programs during treatment are safe and effectively counteract some systemic therapy induced muscle alterations in breast cancer (5) and germ cell cancer patients (4). In this presentation, we will present some recent findings on the detrimental effects of systemic therapies on skeletal muscles, how exercise during treatment can be used to counteract some of these side effects, and finally discuss how exercise during treatment may induce beneficial effects on cancer prognosis.

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**A BEHAVIOR CHANGE PERSPECTIVE ON PHYSICAL EXERCISE DURING CANCER TREATMENT**

DEMMELEMAIER, I.

UPPSALA UNIVERSITY

Physical exercise during cancer treatment has beneficial effects on fitness, fatigue, psychological wellbeing, quality of life and oncological treatment completion. However, maintaining or increasing physical exercise during treatment may be challenging and require specific behavioral strategies. Research in cancer and other long-term disease populations suggests there are some specific behavior change techniques that enhance motivation and performance of physical exercise: information about health gains, use of behavioral goal-setting/planning, self-monitoring of physical exercise, social support and reminders. Communication strategies such as motivational interviewing may be useful as it enables individualized support for physical exercise, rather than providing general recommendations. This presentation will provide an overview of relevant theory and empirical findings, and point out knowledge gaps that need to be addressed in future studies. The target audiences are clinicians, researchers and anyone else interested in a behavior change perspective on physical exercise.

**12:00 - 14:00****PS-PL03 DOES DNA VARIATION REALLY INFLUENCE EXERCISE TRAINING ADAPTATION?****DNA VARIATION EXERTS A SIGNIFICANT INFLUENCE ON EXERCISE TRAINING ADAPTATION.**

BOUCHARD, C.

PENNINGTON BIOMEDICAL RESEARCH CENTER

Studies of cardiorespiratory fitness (CRF) will be used to make the case that there is a substantial genetic component to trainability. The hypothesis that there is a genetic component to variability in CRF trainability is supported by several complementary lines of evidence. Comparisons of training response among inbred mouse strains and breeding experiments with outbred rats have concluded that there is a substantial genetic component to the gains in maximal running distance or time. Four exercise training experiments performed with pairs of monozygotic twins have generated highly concordant findings with a substantial degree of within twin pair resemblance in CRF training response. Finally, these observations were amplified by the results of the HERITAGE Family Study, which showed that the heritability of CRF response to a 20-week exercise program reached 47%. Given this level of evidence, why is it so difficult to define the genetics of trainability at the molecular level? In spite of the spectacular advances in our understanding of the human genome, it is a humongous task to define the genomic basis of complex human traits including exercise-related phenotypes. Among the reasons, CRF trainability is a highly complex biological multi-organ process; correlating genotype with phenotype is a complicated undertaking, even in simpler organism such yeast; DNA variants of relevance to CRF trainability often reside in enhancers, repressors and other regulatory motifs impacting gene expression in subtle ways; similarly, such variants could also impact CpG islands sequences with potential influences on epigenetic marks and gene expression; redundancy is ubiquitous in metabolic pathways and networks, which can further attenuate the signal from genotype to phenotype; and, importantly, complex traits (such as CRF trainability) are not modulated by only a few genes with large effect sizes as once thought. Indeed among the lessons learned from GWAS, complex multifactorial traits are strongly influenced by polygenic systems defined by hundreds or thousands of loci, characterized by alleles with small to very small effect sizes. Because human trainability has a highly complex underlying biology, it is not a sufficient reason to abdicate and conclude that it is not possible to define the molecular basis of the genetic component recognized by both animal model and human studies. With advances in genomic technologies, computational biology and bioinformatics, now is not the time to quit trying!

**DNA VARIATION DOES NOT EXERT A SIGNIFICANT INFLUENCE ON EXERCISE TRAINING ADAPTATION**

JOYNER, M.J.

MAYO CLINIC

In this talk I will highlight evidence questioning the claim that DNA sequence variation exerts a major influence on exercise training adaptations. My main argument centers on the lack of relationship between DNA variation and canonical physiological determinants of exercise capacity most notably cardiac output and blood volume. Likewise there is little current data to suggest that DNA variation explains more than a tiny fraction of the physiological factors that operate at every level of the so-called oxygen transport cascade. Finally, in inbred domestic and experimental animals selected (or engineered) for various traits it is possible to observe a tight linkage between “genotype and phenotype”. Unfortunately this is not possible for complex traits in “outbred” humans.

15:30 - 17:30

**IS-PN05 TOWARDS BETTER QUALITY OF LIFE WITH DIETARY NITRATE SUPPLEMENTATION****BEETER TEETH: INTERACTIONS BETWEEN DIETARY NITRATE AND THE ORAL MICROBIOME**

EASTON, C.

UNIVERSITY OF THE WEST OF SCOTLAND

Background:

Nitric oxide is a multi-functioning signaling molecule that regulates many key biological processes that include: cellular respiration, smooth muscle contraction, blood flow, glucose homeostasis, and host defence. Endogenous production of nitric oxide diminishes with ageing and a reduced availability of nitric oxide is a risk factor for various cardiovascular diseases. However, nitrate contained in green leafy vegetables can be converted to nitrite by bacteria in the mouth and further reduced to nitric oxide in certain physiological conditions. Dietary nitrate supplementation has been found to have ergogenic effects in some exercise contexts and may have therapeutic applications.

Focus of this invited session:

Frequent consumption of carbohydrates may cause oral acidosis and the propagation of acidogenic bacteria leading to cavities and gum disease. While saliva can provide a buffer, its efficacy is reduced in athletes whose salivary flow rate is reduced by elevated breathing rates and dehydration. These effects may explain why elite athletes have significant levels of periodontal disease which can be severe enough to negatively impact performance. Gum disease is also highly prevalent in the general population with half of all adults experiencing some symptoms and a significant minority displaying signs of advanced disease. Although treatment options are limited, data from our lab has shown that nitrate-rich beetroot juice can increase the pH of saliva and significantly alter the composition of the oral microbiome in favour of dental health. We have also shown that the abundance of certain species of oral bacteria can influence the rate at which nitrate is reduced to nitrite which gives weight to the suggestion that oral and cardiovascular health are inextricably linked. This presentation will discuss whether dietary nitrate supplementation can mitigate the negative effects of carbohydrate ingestion on the oral health of athletes and whether it can have therapeutic application for patients with gum disease.

**BEETER PATIENTS HEALTH: DIETARY NITRATE SUPPLEMENTATION AND EXERCISE IN CHRONIC DISEASES**

ALLEN, J., PORCELLI, S.

UNIVERSITY OF PAVIA

Poor cardio-respiratory fitness and inactivity are independent predictors of morbidity and mortality in patients with chronic pathological conditions. The limitations on exercise tolerance has been attributed to several factors including impairments in cardiac function, reduced tissue perfusion, mitochondrial and skeletal muscle dysfunction. Many of these disease-related, physiological maladaptations have previously been identified as potential targets for nitric oxide (NO) restorative effects. Therefore, strategies to increase NO bioavailability would appear to be an attractive target to improve exercise tolerance and health in these populations. This presentation will present data from the literature to highlight the therapeutic benefits and potential of inorganic dietary nitrate on various disease conditions, discussing about contrasting findings and future possible applications

**“BEETER AGING” EFFECTS OF DIETARY NITRATE SUPPLEMENTATION ON EXERCISE EFFICIENCY AND MUSCLE CONTRACTILE PROPERTIES IN ELDERLY PEOPLE**

RASICA, L.

NATIONAL RESEARCH COUNCIL

Ageing is a physiological condition characterized by reduced exercise tolerance. Among the others, a reduced exercise efficiency and an impaired muscle function are two of the main contributors to the limited amount of daily activities that elderly usually perform. It has been demonstrated that mitochondrial dysfunction is a key factor in the reduced exercise efficiency with age (Conley et al. *Exp Physiol* 2013). However, it is also known that elderly people, differently from young population, are characterized by muscle weakness due to an overall loss of skeletal muscle tissue as well as to an impairment of excitation-contraction coupling (Lamboley et al. *J Physiol*, 2016). Several studies demonstrate that dietary nitrate (NO<sub>3</sub><sup>-</sup>) supplementation positively influences skeletal muscle function and exercise performance in young subjects. The ergogenic effects are mainly due to improved mitochondrial efficiency and reduced ATP cost of contraction. More recently, studies on mice suggest an effect of dietary NO<sub>3</sub><sup>-</sup> supplementation on contractile force in fast-twitch muscle fibers after, mainly due to an increased cytoplasmic free calcium (Ca<sup>2+</sup>) concentration and enhanced calcium handling proteins expression (Hernandez et al. *J Physiol*, 2012). Similarly, dietary NO<sub>3</sub><sup>-</sup> supplementation enhanced peak force response to low-frequency electrical stimulation in young subjects (Haider and Folland *MSSE*, 2014; Hoon et al. *EJSS*, 2015). This presentation will discuss the effects of dietary NO<sub>3</sub><sup>-</sup> supplementation on exercise efficiency and muscle contractile properties in elderly, highlighting the potential benefits of this intervention to counteract negative effects of aging and improve life quality.

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## IS-AP01 NEUROMECHANICS OF PERFORMANCE AND FATIGUE DURING CYCLING

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### NEUROMECHANICS OF PERFORMANCE AND FATIGUE DURING LOCOMOTION: MUSCLE MECHANICS AND ENERGETICS IN CYCLING

BRENNAN, S., LAUBER, B., SIDHU, S.

LIVERPOOL JOHN MOORES UNIVERSITY

#### INTRODUCTION:

Locomotion movements like running are characterised by repeated patterns of muscle contractions to generate the required forces and mechanical work for propulsion. The conditions in which these muscle forces and work is produced is related to the overall energy cost. Cycling is a useful movement pattern to examine the muscle mechanics of locomotion movements because of the ability to influence the muscle force and velocity requirements independent of the overall power output. While the overall power output is important for performance in cycling; that power must come from muscle contractions with different mechanical demands depending on factors like cadence and resistance. This talk will discuss muscle mechanics during cycling, how it changes with factors such as cadence, and how that relates to preferred movement patterns.

#### METHODS:

This talk will present results from studies utilising B-mode ultrasound, isokinetic dynamometry, electromyography, and musculoskeletal modelling to understand how the overall mechanics and energetics of submaximal cycling relate to the underlying muscle mechanics. It will discuss how cadence influences the capacity for force, power and efficiency in the vastus lateralis (VL) muscle, and how that might relate to the most economical and preferred cadence selection.

#### RESULTS:

Despite maintaining consistent joint kinematics and therefore whole muscle length changes across a broad range of cadence conditions, cycling at a submaximal power output with different fixed cadences resulted in significant changes in the muscle mechanics at a fascicle level. Low cadences were characterised by a greater range of VL fascicle operating lengths compared to higher cadences. However, when fascicle length changes were mapped to individual power-velocity and efficiency-velocity relationships, higher cadence conditions benefited from fascicle shortening velocities closer to the peaks of the respective curves.

#### CONCLUSION:

The preference for pedalling at higher cadences than the most economical during submaximal cycling may be driven by changes in muscle mechanics. The capacity for power in major muscles like VL may be a key contributor to the determination of the preferred movement pattern in locomotion-type movements. Exactly how the nervous system might detect this information and use it to iteratively control the preferred movement pattern remains to be determined.

Topic: Biomechanics

Presentation: IS-AP01 Neuromechanics of performance and fatigue during cycling

### NEURAL AND BEHAVIOURAL RESPONSES TO CYCLING

LAUBER, B.

UNIVERSITY OF FRIBOURG

Cycling is one of the most common modes of transport and amongst the most popular sports around the world. Similar to walking or running, cycling is characterized by a rhythmical movement pattern; distinguishing these types of movement from other forms of motor behaviour. During fixed-gear cycling, the only way to change the velocity is by altering the cycling cadence. Changes in cadence does not only require the nervous system to modulate its activity, but also has an influence on physiological parameters such as oxygen uptake, and ultimately influence motor performance. In this talk, I will discuss how the central nervous system is involved in the control of cycling and how the activity of different sections of the central nervous system (e.g. the brain versus the spinal cord) modulate with variations in cycling cadence using specific electrophysiological measures such as transcranial magnetic stimulation (TMS). I will specifically focus on how cycling at a preferred cadence might influence the central nervous system differently from cycling at other fixed cadences; and I will put this into perspective with other physiological parameters such as oxygen consumption and how they all might be related to performance by comparing trained and untrained cyclists.

### ROLE OF GROUP III/IV MUSCLE AFFERENTS ON CENTRAL NERVOUS SYSTEM RESPONSES TO EXHAUSTIVE CYCLING EXERCISE

SIDHU, S.K.

THE UNIVERSITY OF ADELAIDE

With the onset of exercise, contraction induced chemical and mechanical stimuli begin to activate molecular receptors located on the terminal end of both group III and group IV nerve fibers with their receptive fields within the skeletal muscle. The exercise induced activation of these receptors increases the spontaneous discharge of the thin fibre afferents that project via the dorsal horn to various spinal and supraspinal sites within the central nervous system. We recently conducted a series of studies to mechanistically study the influence of feedback from the group III/IV muscle afferents on the development of central fatigue, and the changes in responsiveness of cortical vs. spinal neuronal projections to both the exercised and non-exercised muscle groups during cycling exercise. In this talk, I will address the role of group III/IV muscle afferent feedback during locomotion. I will provide an overview of the non-invasive neurophysiological methods employed in these studies, and how they can be used to provide insights into how the central nervous system responds to fatigue during locomotor exercise. Finally, I will provide evidence on the fatigue-related effect of group III/IV muscle afferents using a pharmacological model in facilitating the development of central fatigue and altering the excitability of the motor cortex and spinal motoneurons in humans during locomotor exercise.

## IS-AP05 HOW TO PREVENT HAMSTRING INJURIES IN SOCCER - A NEUROMUSCULAR PERSPECTIVE

### ASSESSMENT OF QUADRICEPS AND HAMSTRINGS COACTIVATION IN RELATION WITH HAMSTRING INJURY IN SOCCER PLAYERS.

NAVARRO, E.

UNIVERSIDAD POLITÉCNICA DE MADRID

Muscular imbalance has been investigated principally in soccer using isokinetic machines, instrumented Nordic hamstring device, or dynamometers. Muscle strength disorders has also been measured through electromyography showing that altered muscles activation patterns can indicate a possible injury risk or fatigue. The long term objective of our group is to develop a battery of test which could be used in the future for predicting the risk of Hamstring strain injury in soccer. Since 2014 we have been measured players from football teams of Madrid Province as Rayo Vallecano (Junior), Real Madrid (first team), Atletico de Madrid (First team and Juniors), Getafe FC (First Team) obtaining data from more than 100 soccer players.

Research #1. The purpose of this study was to examine the electrical activity of muscles in different exercises in relation to the prevention and rehabilitation of the hamstring strain injury in soccer players. Twelve professional soccer players (age=20.6±1.5 years, weight=69.3±7.1 kg, height=177.5±5.1 cm) acted as subjects for the study. Muscle activity was measured using surface wireless electromyography sensors during the five repetitions of two therapeutic exercises: the monopodal squat and forward lunge, both performed with an external load of 30% of the player's body weight. The root mean squared amplitude related to maximum voluntary isometric contraction was considered as the dependent variable. Results: Muscles activate differently in the dominant leg as compared to the non-dominant leg ( $p<0.004$ ) especially in the monopodal squat. In both the forward lunge ( $p<0.05$ ) and the monopodal squat ( $p<0.05$ ), a significantly greater activation of the vastus medialis and the vastus lateralis muscles were found compared to the rectus femoris, while similar activation patterns were recorded for the biceps femoris and semitendinosus muscles ( $p>0.05$ ). Interestingly, the activation of the quadriceps was higher in the monopodal squat but the hamstrings to quadriceps ratio (H:Q) was similar in both exercises ( $p>0.05$ ). When performing a monopodal squat, activity in quadriceps was  $56\pm 15\%$  of its maximum voluntary contraction while the hamstrings reached almost the half that value ( $29\pm 13\%$ ), giving an H:Q ratio of  $0.50\pm 0.2$ . Conclusions: The results suggest that electromyography data of these submaximal exercises could be used for the prevention and rehabilitation in soccer for assessing muscle imbalance and co-activation ratios.

Research #2. The purpose of this study was to analyze the intramuscular activation pattern of the quadriceps and hamstrings and H/Q coactivation ratio in professional soccer players and physically-active subjects without using MVIC. The sample was composed of 68 subjects: 17 professional soccer players from the Spanish first division, 17 from second division B, 17 from the under 18-premier league, and 17 physically-active male subjects. Tests involved three strength exercises during which the activity of the quadriceps and hamstrings was measured by surface electromyography (sEMG). Intramuscular pattern (%RMS) and H/Q ratio (RMS) were determined. Specific activation patterns were observed in the quadriceps (VM > VL > RF) and the hamstrings (ST > BF), with significant differences among muscles ( $p<.01$ ). The H/Q ratio obtained was  $0.17 (\pm 0.18)$  for lunge,  $0.20 (\pm 0.10)$  for single-leg squat and  $0.17 (\pm 0.10)$  for squat. The mean H/Q ratio for the three exercises was  $0.18 (\pm 0.09)$ . Differences were only significant between the legs of physically active subjects, as compared to professional soccer players ( $p < .01$ ). These muscle activation patterns and H/Q ratios could be useful when assessing the risk for injury in professional soccer players without using MVIC.

### ANALYSIS OF NEUROMUSCULAR CHARACTERISTICS BY TENSIOMYOGRAPHY IN RELATION WITH HSI IN PROFESIONAL SOCCER PLAYERS

GONZÁLEZ, C.

UNIVERSITY FRANCISCO DE VITORIA, SPAIN

The neuromuscular properties of athletes can be evaluated by tensiomyography (TMG), a non-invasive technique that, through a portable device, measures the properties of the superficial muscles through a contraction induced by electrostimulation- (Valencic and Knez, 1997; Valencic and Djordjevic, 2001). TMG provides information of muscle tone (Pišot, et al., 2008) fatigue (García-Manso, et al., 2011), explosiveness and imbalances and asymmetries (García-García, 2013). It is a very interesting tool in the prevention of injuries, and in the different phases of rehabilitation after an injury. Another of the relevant aspects of TMG is research on muscle stiffness, since muscle stiffness is linked to the production of strength and power during sport actions (Gil, et al., 2015), but it is also associated with injury. In our studies, we have evaluated many professional soccer players. In them we have seen that: both, lateral and functional asymmetries are at risk of injury, that when a muscle is very explosive and very stiff, the risk of muscle tear is high, and when a muscle chain or a single muscle compared to the rest, lacks strength or is slow, there is also a clear risk of injury. In our studies we have found, with respect to the knee extensor muscles, that vastus medialis and vastus lateralis muscles are faster and with better strength values than the rectus femoris ( $p<0,05$ ), which always has worse explosive and strength data, which unbalances the anterior chain. In relation to hamstrings, the biceps femoris is faster and stronger than the semitendinosus ( $p<0,05$ ), which is the muscle with the worst data of all those evaluated in the flexo-extensor chain. As for the Q/H ratio, there is usually asymmetry due to the very good values of the vastus muscles and the bad data of the semitendinosus and sometimes of the biceps femoris. All these imbalances increase the risk of injury, both in rectus femoris, biceps femoris and semitendinosus. In the preventive programs that we have applied based on tensiomyography data, we have reduced the number of injuries (40%), In these individualized preventive programs we have used exercises based on scientific evidence regarding the muscle activation they generate, in order to correct asymmetries. TMG has proven to be a useful tool in the prevention of injuries in soccer players.

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García-manso, J; Rodríguez-Ruiz, D; Rodríguez-Matoso, D; de Saa, Y; Sarmiento, S; & Quiroga, M (2011) Assessment of muscle fatigue after an ultra-endurance triathlon using tensiomyography (TMG), *Journal of Sports Sciences*, 29:6, 619-625

**FUNCTIONAL ASSESSMENT OF THE HAMSTRINGS ACROSS A RANGE OF RUNNING SPEEDS.**

LAKE, M.

LIVERPOOL JOHN MOORES UNIVERSITY

The rate of hamstring strain injury (HSI) re-occurrence is very high and has been increasing annually despite the abundance of screening tests and return to play criteria. Hamstring muscle fatigue and soreness would be expected to rise as players try to adapt to training that involves increasing bouts of high-speed running. Fatigue due to high training load and reduced recovery time has been suggested to play a key role in the development of HSI. Recently, we have been exploring new methods to assess functionality and recovery of the hamstrings after high-speed running in order to reduce injury risk. Our previous work has indicated that increases in activation levels of the hamstrings with running speed are highly repeatable and linear and could form the basis of a diagnostic test of normal neuromuscular performance. To evaluate this, we have conducted a series of studies to examine the influence of both fatigue and prior hamstring injury on hamstring muscle activation patterns with increasing running speed.

Example Study 1. Electromyography (EMG) of the medial (Semitendinosus, ST) and lateral (Biceps femoris, BF) hamstrings were recorded in 10 team sport athletes during five running speeds on a treadmill (3.5m/s – 4.8m/s) both before and after they performed a bout of 15 maximal 30m sprints. We focused on the largest burst of activity of the hamstrings in late swing when they were eccentrically active. We found that BF significantly reduced activation levels by 11% ( $p < 0.002$ ) with fatigue and the ST had a tendency to increase activation levels by an average of 4% with fatigue. The decreases in BF and increases in ST were most evident at the faster running speeds and it was thought that this represented some degree of compensatory activity of the ST.

Example Study 2. EMG of the ST and BF were recorded during treadmill running (3.5m/s – 5.5m/s) in six elite soccer players who were recovering from a hamstring injury. ST and BF burst magnitudes increased linearly by 25-35% over that speed range for most players. One player showed large non-linear increases in ST EMG activity across that speed range (129%) and relatively low activation levels of the BF (BF was the recovering muscle). Again, this might indicate compensatory ST activity to cope with diminished activation levels of the recovering muscle. After a further two weeks of running training, he was re-tested and the increases in ST activation with speed had reduced to normal levels (24% over the same range).

These investigations provide insight regarding possible compensatory mechanisms between the hamstring muscles during fast running and hence such assessments are likely beneficial in the prevention of re-injury. By monitoring changes in neuromuscular activation with running speed, it is possible to identify whether previously injured muscles are likely ready for the increased demands of high-intensity running.

**IS-SH01 YOUTH SPORTS AND COMBAT SPORTS: A RE-EXAMINATION****SPARRING: THE SWEET SCIENCE OF REFLEXIVE SOCIAL COOPERATION**

LEWANDOWSKI, J.

UNIVERSITY OF CENTRAL MISSOURI

Global participation in the sport of boxing is widespread among youth, especially in urban areas with high concentrations of ethno-racial division and socio-economic marginalization. Generally speaking, boxing in such contexts is viewed as a sport in which youngsters (mostly male) are able to channel the arbitrary violence and aggression of their everyday lives in the controlled violence of an organized sport. Youth boxing, in other words, is construed as a sport that fosters self-discipline, structure, and respect, and, moreover, can serve as an antidote to the random violence of 'the street' for urban youngsters. This paper challenges such a stereotypical account of youth participation in the sport of boxing, especially in the urban milieu. While boxing may teach the art of controlled violence, for health reasons (e.g., repeated concussive head injuries) youngsters—especially those from impoverished backgrounds—should not compete in the sport of boxing. But, the paper goes on to argue, there is a place for the practice form of boxing known as 'sparring' in the framework of youth sport and community development. Indeed, the practice of sparring in a combat sport such as boxing teaches forms of social cooperation and mutual collaboration that youngsters may not otherwise learn outside of the gym.

**SHOULD BOXING BE PART OF OLYMPIC EDUCATION?**

LOLAND, S.

THE NORWEGIAN SCHOOL OF SPORT SCIENCES

Boxing is morally contested terrain, in particular in its professional or knock out versions. Amateur versions emphasizing technical and tactical skills are less contested but still controversial as they include and reward landing blows to the head and body of an opponent. Can boxing be morally justified as part of Olympic education?

Traditional moral arguments on boxing revolve around health, aggression/violence and respect for persons, and the socializing effects of the sport. Recent analyses conclude that the aims of boxing do not fall in line with the ideals of Olympic education, and hence argue that the sport should be discontinued as an event of the Youth Olympic Games (YOG) (Parry 2012; Torres and Parry 2017).

This paper shares this view to a certain extent but maintains that the moral potential of amateur boxing must be recognized (Lewandowski 2007). To that end, the paper provides a review of the goals of the YOG (Loland 2014). Secondly, the paper argues that boxing can be modified in ways that make the sport not only morally acceptable but particularly potent in the realization of YOG goals. An outline of modifications and adaptations in which collaboration and mutual respect between boxers are constitutive elements is developed.

The paper concludes with the assertion that boxing in such modified form should be an obligatory part of Olympic educational programs and a core sport within the YOG.

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**AESTHETIC AND ETHICAL SYNERGIES IN YOUTH COMBAT SPORTS**

ÁVILA DA COSTA, L., LACERDA, T.O.

*FACULTY OF SPORT, UNIVERSITY OF PORTO*

While combat sports are typically associated with violence, this paper seeks to explore the aesthetic and ethical dimensions of such sports. Combat sports, on this account, have little to do with violence. Instead, like other sports, combat sports are rich with narrative and drama permeated by certainty and uncertainty, predictability and unpredictability, the expected and the unexpected, the pleasant and the repulsive. In this regard the tension between the narrative of combat and the ethical obligation to show respect and esteem for an opponent is especially acute in combat sports. Indeed, how can one simultaneously show respect and esteem for an opponent while trying to excel in knocking him/her unconscious? Combat or fighting sports challenge athletes to find ways to move aesthetically and ethically, not merely violently. This paper explores the pedagogical potential of combat sports among youth with an eye toward the synergy of aesthetics and ethics of combat. The paper examines different combat sports, and considers how combat sports foster learning at young ages and can contribute to an aesthetic-ethical way of competing and, indeed, existing, by enriching youngsters lives and providing an alternative to utilitarianism and hedonism.





## Pre-recorded Oral presentations

### OP-AP01 Training and testing

#### A SHORT-TERM STRENGTH EXERCISE TRAINING PROGRAM MODULATES SYMPATHO-VAGAL BALANCE IN CHILDREN AND ADOLESCENTS WITH CYSTIC FIBROSIS

ESTÉVEZ-GONZÁLEZ, A.J., DE RAMOS, C.G., SANZ, V., COBO-VICENTE, F., FERNÁNDEZ DEL VALLE, M., SAN JUAN, A.F., DIEZ, I., PÉREZ RUIZ, M., DONADIO, M.V.F.

UNIVERSIDAD EUROPEA DE MADRID

##### INTRODUCTION:

Cystic fibrosis (CF) is a hereditary disease caused by a mutation of the gene that encodes the cystic fibrosis transmembrane regulator protein (CFTR). As a multisystemic illness, CF also affects the nervous system, altering the autonomic function (1). A simple and non-invasive method to analyze the function of the autonomic nervous system is to record the sympathetic-parasympathetic influence, measured through the heart rate variability (HRV). Exercise in healthy children modulates positively the autonomic nervous system, improving the interaction between sympathetic and parasympathetic activity (2). Objective: To evaluate the effect of a short-term exercise strength program on HRV in children and adolescents with CF.

##### METHODS:

A randomized controlled study was carried out in children diagnosed with CF aged 6 to 18 years. Individuals were divided into two groups: control group (CON) and strength training group (ST). Patients treated with beta-blockers, atropine, presenting severe exacerbation or who were under lung transplantation were excluded. HRV was analyzed using KUBIOS and measured using a Suunto watch, while subjects were in lying position without movement or speaking for 5 minutes (3). Patients in the ST completed an individualized guided strength program for 8 weeks (3 sessions of 60 min/week). Training prescription was individualized and based on the 5-RM test (60-80%). Upper and lower limbs exercises were used, including seated bench press, seated lateral row and leg press. A repeated measure analysis for group and time was used to evaluate differences. Significance was set at 0.05 and effect sizes ( $\eta^2p$ ) were reported.

##### RESULTS:

Nineteen subjects with CF (14 boys), were included in the study. Mean age of the sample was  $12.2 \pm 3.3$ , FEV1 (Forced expiratory volume in the first second) z-score  $-1.36 \pm 1.63$  and VO<sub>2</sub>peak (mL/Kg/min)  $41.7 \pm 8.1$ . Patients were randomized in CON (n=11) and ST (n=8). The exercise strength program induced changes in time-domain variables with high effect sizes for both SDNN ( $p=0.08$ ;  $\eta^2p = 0.16$ ) and RMSSD ( $p=0.05$ ;  $\eta^2p = 0.19$ ). Regarding frequency-domain variable, a significant LFnu decrease in ST was found ( $p=0.006$ ;  $\eta^2p = 0.36$ ), while HFnu increased in ST ( $p=0.006$ ;  $\eta^2p = 0.36$ ). LF/HF ratio was significantly ( $p=0.02$ ;  $\eta^2p = 0.25$ ) lower in ST ( $0.63 \pm 0.45$ ) compared to CON ( $1.22 \pm 1.11$ ).

##### CONCLUSION:

A short-term exercise strength training program was able to change sympatho-vagal balance in children and adolescents with CF presenting mild to moderate lung function impairment and good physical condition.

##### References:

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#### A HEAT-AND-MOISTURE EXCHANGING MASK MAY INCREASE THE PHYSIOLOGICAL DEMANDS OF SUBMAXIMAL EXERCISE IN -15 DEGREES CELSIUS.

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##### INTRODUCTION:

Winter endurance athletes such as cross-country skiers have an increased prevalence of asthma (Eriksson et al., 2018, Scand J Med Sci Sport). Heat-and-moisture exchangers (HMEs) such as masks and mouthpieces with a filter to facilitate warming and humidification of inspired air may protect the airways from injury during exercise in cold, dry climates. However, if there is evidence of impaired exercise capacity, athletes will likely avoid using such devices. The aim of this study was to investigate the influence of an HME mask (AirTrim Sport, Vapro AB, Västerås, Sweden) on heart rate (HR), breathing rate (BR), muscle oxygenation (SmO<sub>2</sub>) and perceived exertion at fixed submaximal workloads.

##### METHODS:

23 active, healthy participants without asthma aged  $31 \pm 8$  years (15 men, 8 women) performed a familiarisation test followed by two experimental trials with and without HME in a randomised, crossover design. All tests were performed at a 4% gradient on a motorised treadmill and consisted of a submaximal incremental warm-up followed by a maximal, self-paced 4-min running time trial (TT). During the familiarisation test, participants wore a portable oxygen uptake system (Metamax 3B, Cortex Biophysik, Leipzig, Germany) with the TT used to derive VO<sub>2</sub>peak. Submaximal VO<sub>2</sub> was interpolated to derive speeds estimated to elicit 65, 70, 75 and 90% of VO<sub>2</sub>peak. In two subsequent trials performed in a climate chamber at -15 degrees Celsius, participants ran for 5 min at speeds equivalent to 65, 70 and 75% VO<sub>2</sub>peak, 3 min at 90% and 12 min at 65% VO<sub>2</sub>peak. HR and BR were monitored via a chest harness (LifeMonitor, Equivital, Cambridge, UK); mean SmO<sub>2</sub> from the right and left quadriceps was derived using near infra-red sensors (MOXY, Fortiori Design, Hutchinson MN, USA). Data were summarised as 1 min epochs, taken from 90 to 30 s before the end of each stage. Borg 6-20 rating of perceived exertion (RPE) was reported 1 min before the end of each stage. Data were analysed using repeated-measures ANOVA and linear mixed models. The study was approved by the regional ethical review board and conducted according to the Declaration of Helsinki.

##### RESULTS:

HR was 2.5 beats/min higher during the HME trial (95% CI: 0.3 - 4.6,  $p=.03$ ). In the male participants only, SmO<sub>2</sub> was lower during the HME trial than control (-2.3%, 95% CI: -0.1 - -4.5,  $p=.04$ ). The female participants reported higher RPE (0.65 AU) during the HME trial ( $p=.009$ ). There was no difference in BR between the HME and control trials.

#### CONCLUSION:

Despite potentially small increases in dead space and resistance to breathing, an HME did not affect BR during submaximal exercise in -15 degrees C. However, higher HR during exercise with an HME, as well as lower SmO<sub>2</sub> in the male participants and higher RPE in the female participants, indicates slightly higher physiological stress during steady-state exercise with an HME. It would therefore be relevant to investigate whether an HME affects maximal exercise capacity in sub-zero temperatures.

### RELATIONSHIP BETWEEN DIFFERENT LOADS IN RESISTED SLED SPRINTING, MAXIMUM STRENGTH AND CHANGE IN KINEMATICS

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#### INTRODUCTION:

Sprint performance is an essential skill to target within field sports and track and field [1]. Resisted sprint training is believed to increase strength specific to sprinting [2, 3]. It is well-known that an athlete's kinematics change with increasing sled load [4]. However, to our knowledge, the relationship between different loads in resisted sled sprinting (RSS), maximum strength, and change in kinematics is unknown. The main purpose of this study was to examine the relationship between change in kinematics and 1RM back squat (BS) and hip thrust (HT) strength measures. A second aim was to examine the relationships between 1RM, vertical jumps (countermovement jump and drop jump) (CMJ, DJ), and the performances obtained by athletes in different sprint distances (10-40m) with different loading conditions.

#### METHODS:

Thirty-three athletes (20 sprint, 23 field) were recruited to complete 3 testing days. Day 1 was a familiarization session. On day 2 and 3 participants completed 1RM in hip thrust and back squat and a series of RSS with loads of 0, 10, 20, 30%V<sub>dec</sub> and vertical jumps. Timing gates (Brower Timing Systems, Draper, UT USA) were set up at 5-meter intervals to measure sprint time and average velocity. Kinematics were measured using two high-speed cameras (HSC). Dartfish software was used to compute angles, which were measured at toe-off and at touch down. For the 1RMs the protocol used, was the common protocol from the National Strength and Conditioning Association. Participants performed CMJs and DJs on two synchronized single axis force platforms (Pasco, Roseville, California, USA; Model number: 2141) and subsequent analyzes was completed with NMP Forcdeck software (ForceDecks v1.2.6.109). Pearson's correlation coefficient ( $r$ ) was used to investigate the relationship between levels of strength and kinematic variables at each RSS load, as well as the relationships between jump, strength, and sprint variables.

#### RESULTS:

Significant negative correlations were found between strength measures and percentage change in joint angle (hip  $r = .40$ ;  $r = .44$ , knee  $r = .42$ ;  $r = .56$ ) for the different loading conditions for acceleration and maximum velocity phase. Furthermore, negative correlations were displayed between maximum strength and sprint time (10, 15, 20, 25, 30, 40m sprint time,  $r = .44 - .61$  BS;  $r = .57 - .71$  HT) at all different loading conditions and between CMJ height and sprint time ( $r = .45 - .73$ ). Unexpectedly no significant correlations were found between peak power and sprint time. Moreover, maximum strength measures and jump performance measures showed no correlations, except for BS and peak power of the CMJ ( $r = .77$ ).

#### CONCLUSION:

It could be concluded that maximum strength measures explain much of the response of athletes during RSS. Suggesting that stronger athletes might be able to handle a higher overload without displaying changes in some sprint kinematics.

1. Lahti et al. (2019)
2. Cahill et al. (2019)
3. Kawamori et al. (2014)
4. Osterwald et al. (2020)

### EFFECTS OF A SIMULATED SPACEWALK UNDERWATER ON EXECUTIVE FUNCTIONS

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#### INTRODUCTION:

This study explored the effects of a simulated extra-vehicular activity (EVA) during submersion involving exercise and several cognitive/motor tasks on performance of the executive functions (EF) shifting and inhibition. EVAs performed by humans in microgravity, such as on the International Space Station (ISS), call for high cognitive and motor performance during long-time physical workload with little margin for error. Executive functions (i.e., switching, inhibition, updating) are believed to form the basis for cognitive performance with influences on decision-making, shifting between tasks or the inhibition of prepotent responses, and are therefore highly relevant for productivity, safety and overall mission success in everyday life and during strenuous EVA. Lower body continuous aerobic exercise (AE) (e.g., on a bicycle ergometer) can modulate EF performance, but little knowledge exists about the application for upper-body AE (which is required during an EVA), and especially the combination of AE with cognitive/motor tasks during an EVA activity. Because astronauts' practice for EVA in the pool for simulating weightlessness, here an underwater setting was used to implement EVA-specific AE and tasks.

#### METHODS:

In a crossover design, 8 divers (age:  $25.8 \pm 4.1$ ; 4 females, 4 males) performed two conditions (e.g., EVA; Inactivity) in shallow-water submersion (3-5 m). During EVA, participants performed 30 min of moderate, followed by 30 min of high intensity upper-body AE intervals paired with cognitive/motor tasks (e.g., fast translations along underwater mock-ups following a tether protocol, transportation of payload, routing of cables, allocation of connectors...). During inactivity, participants stayed in a submerged and neutrally buoyant position. Both conditions implied cognitive testing for the times PRE, MID (after the first 30 min) and POST (after the second 30 min). For both cognitive tasks, reaction times (RT) and response accuracy (ACC) was calculated for scenarios requiring inhibition (Eriksen Flanker task) or switching (Number/Letter task) ability, respectively.

#### RESULTS:

Switching: RTs were shorter after Inactivity compared to EVA with no interaction of time\*condition for RT and ACC scores. Inhibition: RTs were shorter for EVA compared to Inactivity. ACC showed a time\*condition interaction ( $F(1,873, 13.108) = 5.182, p=0.023$ ) with higher scores for MID and POST measurements during Inactivity compared to EVA.

**CONCLUSION:**

This pilot data suggests that the specific physical exercise and tasks performed during simulated EVA might affect switching and inhibition selectively, although a greater sample size is needed for confirmation. This work might help to increase the understanding of interactions between specific exercise modalities and cognitive performance. Possible applications lie within the scope of safety for EVAs outside the international space station and during long-time space travel.

**A STUDY ON PREDICTION EQUATION OF PHYSICAL FITNESS AGE FOR KOREAN ADULTS**

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**INTRODUCTION:**

The decline in physical fitness and physiological function with age after adulthood is an inevitable providence of nature. In Korea, to promote the physical fitness and physical activities of its citizens, the Ministry of Culture, Sports and Tourism introduced a national fitness award program, National Fitness 100, that scientifically measures and evaluates physical fitness, and provides customized exercise prescriptions. Since 2011, the beginning of the pilot project, the number of program participants has increased yearly. To provide effective exercise programs, the physical fitness age (PFA) according to the physical fitness level rather than the actual age should be considered, and it is important to estimate PFA that can be used in the field. This study aimed to develop prediction equations that can estimate PFA of Korean adults at the young age (19-40yrs), the middle age (41-64yrs), and the old age (65-80yrs).

**METHODS:**

The subjects were 122,842 individuals who participated in the 'Korean national fitness assessment' and 'National Fitness 100' from 2009 to 2014. Measurements of Body mass index (BMI), relative grip strength, modified sit-ups, sit-and-reach test, 20m PACER, shuttle run, and standing long jump were taken for the young age and the middle age. BMI, 6-minute walk test, 2-minute step-in-place, relative grip strength, chair stand, sit-and-reach, 3m up-and-go, and figure of 8 walk test were measured for the old age. Stepwise regression analysis was applied in the development of prediction equations by gender and age.

**RESULTS:**

The equations of the following were developed. PFA for the young male= $22.321 - .088*(20m PACER) + .317*(BMI)$ , PFA for the young female= $24.486 - .143*(20m PACER) + .304*(BMI)$ , PFA for the middle male= $66.644 - .044*(standing long jump) - .069*(20m PACER) - .201*(weight) - .075*(modified sit-ups) + .269*(shuttle run) + .320*(BMI)$ , PFA for the middle female= $66.814 - .098*(standing long jump) - .113*(modified sit-ups)$ , PFA for the old male= $84.795 + .093*(figure of 8 walk test) - .100*(chair stand) - .122*(weight) - .102*(relative grip strength) - .060*(sit-and-reach) + .147*(3m up-and-go)$ , PFA for the old female= $80.577 + .097*(figure of 8 walk test) + .306*(3m up-and-go) - .280*(weight) - .088*(relative grip strength) - .069*(sit-and-reach) + .393*(BMI) - .088*(chair stand) - .011*(2-minutes step-in-place)$

**CONCLUSION:**

The evaluation of physical fitness by factor and the level of physical fitness by PFA can inform the degree of physical aging and motivate the exercise to improve physical fitness. Therefore, it will be useful to promote physical activity and to form health related to physical fitness maintenance strategy by estimating PFA by each age group. Also, prediction equations of PFA from this study will be used as an excellent tool for prescribing appropriate exercise programs.

**NEW DATA-BASED SECONDARY EXHAUSTION CRITERIA FOR CARDIORESPIRATORY FITNESS TESTING IN HEALTHY ADULTS ACROSS THE LIFESPAN**

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**INTRODUCTION:**

The maximal volume of oxygen uptake ( $\dot{V}O_{2max}$ ) is a strong risk factor and important measurement as described in a recent statement by the American Heart Association, and should be assessed as a vital sign (1). Physical exhaustion is necessary to determine  $\dot{V}O_{2max}$  but making the distinction between those subjects who have reached exhaustion and those who did not remains difficult. To address this challenge our aims were to determine age-dependent cutoff values for secondary exhaustion criteria for a general population that is free of exercise limiting chronic disease conditions, to provide a descriptive analysis of the percentage of participants reaching commonly-used exhaustion criteria during CPET, and to analyze their oxygen uptake at the respective cut-off level in order to quantify the impact of a chosen criterion on the respective  $\dot{V}O_{2}$  values.

**METHODS:**

Data from the COMpLETE-Health Study were analyzed involving participants from 20-91 years of age. All participants underwent an exercise test until maximal voluntary exertion using a cycle ergometer. Breath-by-breath gas analyses and HR were measured continuously and  $\dot{V}O_{2peak}$  was assessed as the highest volume of oxygen uptake over 30 seconds during the test.  $\dot{V}O_{2}$  was further assessed for the time points when respiratory exchange rates (RER) reached 1.0, 1.05, 1.10, and 1.15 and when age-predicted maximal heart rate (APMHR) reached 85%, 90%, 95%, and 100%. To determine new exhaustion criteria, based on RERmax and APMHR, one-sided lower tolerance intervals for the tests confirming  $\dot{V}O_{2}$  plateau status were calculated using a confidence level of 95% and a coverage of 90%. A  $\dot{V}O_{2}$  plateau was defined as an increase in  $\dot{V}O_{2}$  during the final two minutes which was <50% of the corresponding increase in the submaximal intensity domain.

**RESULTS:**

A total of 526 participants were included in the study (274 males and 252 females). Participants were nearly equally distributed over all age decades from 20 to 80+. A  $\dot{V}O_{2}$  plateau was present in 32%. There were only minor differences in any secondary exhaustion criteria between participants with and without a  $\dot{V}O_{2}$  plateau. New exhaustion criteria according to the tolerance intervals for the age group of 20 to 39 years are: RERmax  $\geq 1.13$ , APMHR210  $\geq 96\%$ , and APMHR208 93%; for the age group of 40 to 59 years: RERmax  $\geq 1.10$ , APMHR210  $\geq 99\%$ , and APMHR208 92%; and, for the age group of 60 to 69 years: RERmax  $\geq 1.06$ , APMHR210  $\geq 99\%$ , and APMHR208 89%.

**CONCLUSION:**

The proposed high cut-off values for secondary criteria need to be chosen to reduce the risk of underestimation of VO<sub>2</sub>max. Lower values would increase false positive results, assuming participants are exhausted although, in fact, they are not.

Reference:

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## VALIDITY OF MAXIMAL FIELD TESTS FOR AEROBIC FITNESS EVALUATION IN RECREATIONAL FOOTBALL

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### INTRODUCTION:

Recreational football interventions are deemed to improve VO<sub>2</sub>max across ages and genders (1). Intermittent endurance field tests are a viable strategy to assess football players' improvements in VO<sub>2</sub>max in order to control training interventions' outcomes (2, 3). This study aimed at examining the suitability of three versions and two levels of the Yo-Yo intermittent tests for assessing and tracking aerobic fitness status development in male recreational football players.

### METHODS:

In this study, sixty-six untrained participants (age 39 ± 6 years, VO<sub>2</sub>max 41.2 ± 6.2 ml kg<sup>-1</sup> min<sup>-1</sup>, body mass 81.9 ± 10.8 kg, height 173.2 ± 6.4 cm), engaged in a 12-week recreational football training program were assessed during the Yo-Yo intermittent endurance level 1 (YYIE1) and 2 (YYIE2) tests and the Yo-Yo intermittent recovery level 1 test (YYIR1), and during a treadmill test for VO<sub>2</sub>max assessment, at baseline. Thirty two out of these 66 participants replicated all these tests at post-intervention. An additional group of 30 male age-matched recreational football players that afterwards started the 12-week recreational football program (age 39 ± 6 years, VO<sub>2</sub>max 45.3 ± 5.8 ml kg<sup>-1</sup> min<sup>-1</sup>, body mass 82.5 ± 7.8 kg, height 172.8 ± 5.4 cm) was evaluated at baseline to test cross-validation.

### RESULTS:

Very large associations between the Yo-Yo tests and VO<sub>2</sub>max were observed at baseline ( $r = 0.75-0.77$ ;  $P < 0.0001$ ) and at postintervention ( $r = 0.76-0.82$ ;  $P < 0.0005$ ). After the intervention, very large associations were found between YYIE2 performance and VO<sub>2</sub>max ( $r = 0.65$ ,  $P < 0.0001$ ). Cross-validation revealed small to large differences between the observed and estimated VO<sub>2</sub>max values (1.5–2.96 ml kg<sup>-1</sup> min<sup>-1</sup>) with moderate typical error of estimation (7.9–8.7%) across the tests. Performance in the YYIE1, YYIE2 and YYIR1 tests of ≥ 1760, 480 and 600 m, respectively, indicated good to excellent VO<sub>2</sub>max values.

### CONCLUSION:

The Yo-Yo tests here considered showed robust and consistent criterion validity. The YYIE2 could be a more accurate option to track aerobic fitness development in recreational football players.

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2. Bangsbo, J. et al. *Sports Med*. 2008,38(1):37-51.
3. Schmitz, B. et al. *Front Physiol*. 2018,9:870.

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## BLOOD FLOW RESTRICTION DURING LOW INTENSITY ROWING INCREASES $\dot{V}O_2\text{MAX}$ IN HIGHLY TRAINED ENDURANCE ATHLETES: A 5-WEEKS RANDOMIZED CONTROLLED TRIAL

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### INTRODUCTION:

The present 5-week randomized controlled trial examined the effects of practical blood flow restriction (pBFR) on maximal oxygen uptake ( $\dot{V}O_2\text{max}$ ) during low intensity rowing.

### METHODS:

Thirty-one elite rowers were either assigned to the intervention (INT) or control (CON) group, using the minimization method (Strata: Gender, Age, Height,  $\dot{V}O_2\text{max}$ ). While INT (n=16; 4 female, 12 male, 21.9 ± 3.2 years, 180.4 ± 8.7 cm, 73.6 ± 10.9 kg,  $\dot{V}O_2\text{max}$ : 63.0 ± 7.9 ml/min/kg) used pBFR during boat- and indoor-rowing training, CON (n=15, 4 female, 11 male, 21.7 ± 3.7 years, 180.7 ± 8.1 cm, 72.5 ± 12.1 kg,  $\dot{V}O_2\text{max}$ : 63.2 ± 8.5 ml/min/kg) completed the identical training without pBFR. pBFR of the lower limb was applied via customized elastic wraps. pBFR Training took place three times a week over 5 weeks (accumulated net pBFR: 60 min/week; occlusion per session: 2-times 10 min/session) and was used exclusively at low intensities and during rowing. A spiroergometric ramp test ( $\dot{V}O_2\text{max}$ ; 30-40 W/min increase) on rowing-ergometer and an one-repetition maximum test of the squat exercise (SQ1RM) was employed to assess endurance and strength capacity.

### RESULTS:

Very large and highly significant group × time interactions ( $p=0.001$ ,  $\eta^2=0.26$ ) in favour of INT were found for  $\dot{V}O_2\text{max}$  (63.0 ± 7.0 ml/min/kg to 69.7 ± 9.4 ml/min/kg; +9.1 ± 6.2%, Effect Size = 1.3) compared to CON (63.2 ± 8.5 ml/min/kg to 64.9 ± 8.6 ml/min/kg; +2.5 ± 6.1%, Effect Size=0.3). Also, Power at  $\dot{V}O_2\text{max}$  PVO<sub>2</sub>MAX showed significant group × time interactions ( $p=0.001$ ;  $\eta^2=0.33$ ) in favour of INT (383 ± 121 W to 442 ± 101 W; +15.3 ± 9.7%, Effect Size = 1.4) compared to CON (396 ± 89 W to 408 ± 98 W; +3.1 ± 9.7%, Effect size = 0.3). In contrast, SQ1RM ( $\eta^2=0.01$ ) was not affected by the pBFR intervention for INT (106.2 ± 20.0 kg to 111.9 ± 20.9 kg; +5.4 ± 5.7%, Effect size = 0.8) and CON (99.1 ± 25.1 kg to 103.7 ± 25.4 kg; +4.6 ± 5.3%, Effect size = 1.0). Additionally, training intensity distribution (TID) and total training volume of INT (13.7 ± 4.4 h/wk) and CON (13.0 ± 4.7 h/wk) was similar ( $p=0.953$ ,  $d=0.02$ ).

### CONCLUSION:

This study revealed that 15 sessions of pBFR application with a cumulative total pBFR stimuli of 5h over a 5 weeks macrocycle remarkably increased VO<sub>2</sub>max. This is particularly important as the VO<sub>2</sub>max is considered to be an essential surrogate parameter of rowing performance. Ultimately, pBFR provides a feasible, promising and beneficial complementary training stimulus to traditional rowing training. Thus, pBFR might serve as promising means to improve aerobic capacity in highly trained endurance athletes.

## RECURRENCE OF NULL LIFTS, IN DISABLED ATHLETES IN POWERLIFTING, IN INTERNATIONAL CHAMPIONSHIPS.

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### INTRODUCTION:

Powerlifting (PWL) begins to be practiced by people with disabilities, starting in 1950, in the USA and Europe, but it is only until the Tokyo Paralympic Games in 1964, when athletes with spinal cord injury, compete. From the Paralympics, in Barcelona, the participation of athletes with any physical disability is allowed. These athletes are classified into categories according to their body weight: 10 weight categories for women, from 40 kg to 82.5 kg and 10 categories for men, from 48 kg to 100 kg. In the PWL the athlete executes 1 RM in the bench press exercise, with 3 attempts. The technical gesture of the PWL requires maximum strength, resistance to strength and power. The movement is described as a flexion-extension of arms that moves the bar towards the chest and then superloads the bar, with an extension of the arms [1]. The effectiveness of the lift depends on: the athletes ability to generate a force, combined with a correct technical execution; which implies a symmetrical action of the arms, a grip position with a separation not greater than 81 cm, and a control of the range of movement at the level of the elbow and shoulder joint. In the various official PWL competitions, a high number of null surveys (LN) are identified through empirical observations. There are few studies on this sport [2, 3, 4, 5] and only one study [1] that analyzed in 29 athletes the relationship between technical execution and the number of null lifts (NL) in official PWL competitions.

### METHODS:

The official International Powerlifting Federation (IPF) results of 12 international championships between 2013 and 2018 were analyzed. Sperman was applied for correlations.

### RESULTS:

It was identified that the 901 athletes (3,306 men and 1,851 women) who participated in the 12 championships made a total of 15,965 lifting, of which 7,611 (47.6%) were NL, a figure that can be considered high if compared with a 36% of NL in a PWL world championship, for people without disabilities. Men obtained 49.6% of NL, compared to 53.5% of women. a correlation of  $r = -0.06$  was observed between the % of NL and the weight category. It was not found that in between the 2013 and 2018 championship, the number of NLS ( $r = .21$ ) was progressively reduced.

### CONCLUSION:

It was not identified that the weight category, nor the evolution in the championships, affect the number of LN, however it was identified that women commit more NL. In this sense, observations are required to determine what are the factors that affect the high percentage of NL, including age, training years, or the level of expertise of the judges.

1. Seidel y Zurowska (2014) 2. Allegretti et al. (2014) 3. Andreu & Álvarez (2016) 4. González (2018) 5. Rygula, Plociennik & Lipinska, (2016)

## THE HIGH HUMIDITY GIVES BRONCHODILATION AND NOT INCREASE RESPIRATORY PRO-OXIDANTS INDUCED BY EXERCISE

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### INTRODUCTION:

The lung function and redox state of the respiratory system can be altered by exercise, mainly due to increased lung ventilation and low environmental temperature (1). Under these conditions and as a consequence of increased respiratory flow, the organism is inefficient at saturating with water vapour and tempering inhaled air, which leads to dehydration of the respiratory epithelium and the release of local inflammatory factors mediated by pro-oxidants, generating bronchoconstriction (2). The spirometry and exhaled breath condensate (EBC) are non-invasive methods using for evaluating this phenomenon (3). This study assessed, in recreational cyclists, the influence of high relative-humidity (90%-RH) on the production of respiratory pro-oxidants induced by physical exercise, measured by EBC, and changes in lung function evaluated by spirometry.

### METHODS:

Sixteen participants (4 female) with no history of asthma or respiratory infection completed a previous cardiopulmonary exercise test (VO<sub>2</sub>-peak test) for obtaining the maximum load (watts) of pedalling. The test consisted in 1-hour cycling at 70% of the individual workload achieved in the VO<sub>2</sub>-peak test (70-90 rpm cadence), in a semi-hermetic chamber constructed specially to keep the 90%-RH ( $\pm 24$  °C). The temperature (forehead, mouth, and ambient), and symptoms (dyspnea and leg fatigue) were registered every 5 minutes during the protocol. The spirometry was measured before (rest) and 20 (20-post), and 80 (80-post) minutes after end, while samples of EBC (hydroperoxide [H<sub>2</sub>O<sub>2</sub>]EBC, nitrite [NO<sub>2</sub>-]EBC) and plasma ([NO<sub>2</sub>-]P) were obtained rest and 80-post. The normality of the data was evaluated using the Shapiro-Wilk test. The variation in the temperature values, EBC and plasma pro-oxidants, and spirometry values (FEV<sub>1</sub> and FEV<sub>1</sub>/FVC) were analysed using one-way RM-ANOVA. The statistical software used was GraphPad Prism 8.0. A value of  $p < 0.05$  was considered statistically significant.

### RESULTS:

The cycling exercise was performed at high-intensity (86.0 $\pm$ 7.3 %HR<sub>máx</sub> (220-age), 166 $\pm$ 26 watts). Forehead (36.2 $\pm$ 0.3 °C,  $p=0.230$ ), mouth (35.7 $\pm$ 0.1 °C,  $p=0.184$ ), and environmental (24.0 $\pm$ 0.1,  $p=0.325$ ) temperatures and relative-humidity (90.6 $\pm$ 0.6 %-RH) were stable during the exercise protocol. FEV<sub>1</sub> and FEV<sub>1</sub>/FVC increased at 20-post and 80-post (4.10 vs 4.24 ( $p=0.047$ ) and vs 4.25 ( $p=0.001$ )) and (82.8 vs 86.9 ( $p=0.009$ ) and vs 85.9 ( $p=0.037$ )), respectively. Non-significant increases were found in [H<sub>2</sub>O<sub>2</sub>]EBC (0.22 to 0.24  $\mu\text{mol}\cdot\text{L}^{-1}$  ( $p=0.052$ )), [NO<sub>2</sub>-]EBC (1.54 to 1.71  $\mu\text{mol}\cdot\text{L}^{-1}$  ( $p=0.198$ )), and [NO<sub>2</sub>-]EBC/[NO<sub>2</sub>-]P (0.145 to 0.150 ( $p=0.447$ )).

### CONCLUSION:

A high relative-humidity protects the airway of respiratory pro-oxidants induced by exercise and allows bronchodilation in recreational cyclists.

### References:

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**NEUROMUSCULAR FATIGUE AND PERCEIVED WELLNESS OF YOUTH NETBALL PLAYERS OVER AN INTENSIFIED YOUTH TOURNAMENT**

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**INTRODUCTION**

Youth Netball tournaments commonly consists of consecutive matches played over a short period. The accumulated match-load accrued in a congested period have reported increased perturbations in physiological function and perceive wellness (1). To date, there is limited published data on the time-course changes of neuromuscular fatigue and perceived wellness in response to consecutive matches played by youth netballers. This study examined the time-course changes of neuromuscular fatigue and perceived wellness in an intensified youth netball tournament.

**METHODS**

39 female netball players (14.6 ± 0.5 years, 165.9 ± 4.7cm, 56.5 ± 7.2kg) were monitored over two youth netball tournaments. Players were split into two groups according to match-load exposure time: Low tournament load (LOW) (n = 19) and high tournament load (HIGH) (n = 20). Counter-movement

jump height (CMJ height ) and perceived wellness ratings (soreness, fatigue, sleep, stress, mood) were measured daily for a total of five match-day (MD). Mixed linear model was used to estimate the effects of changes, with MD and group interaction entered as fixed effects and player identity

included as random effects to account for repeated measures on player's matches. The changes were also expressed in standardized units to determine magnitude-based decisions.

**RESULTS**

The between-group differences compared with MD 1 showed a very likely moderate decrease in CMJ height on MD 4 (-8.3 ± 5.6%, 0.7 ± 0.5, 0/2/98) and a likely small decrease on MD 5 (-5.6 ± 7.2%, 0.5 ± 0.6, 2/17/81) in the HIGH group. A moderate likely decrease in perceived soreness was

also observed on MD 3 (-0.9 ± 1.1 AU, 0.7 ± 0.6, 1/9/90) and MD 4 (-0.8 ± 0.9 AU, 0.6 ± 0.5, 1/11/88) with perceived sleep similarly likely reduced on MD 4 (-0.9, ±1.1 AU, 0.6 ± 0.6, 2/11/87) and MD 5 (-0.9, ±0.7 AU, 0.6 ± 0.5, 1/9/90) in the HIGH group. Perceived mood showed a likely

small increase on MD 2 (0.6, ±0.6, 0.5 ± 0.6, 81/17/2) with a likely small decrease in overall wellness on MD 3 (-2.6, ±2.3 AU, 0.5 ± 0.4, 0/9/91) and MD 5 (-2.1, ±3.1 AU, 0.4 ± 0.6, 2/22/76) in the HIGH group. Perceived fatigue and stress were unclear across all MDs.

**CONCLUSION**

The findings suggest that increased exposure to match-load in youth netballers resulted in moderate increases in neuromuscular fatigue and reduced perceived wellness. Practitioners should consider appropriate recovery and rotation strategies in youth tournaments to reduce the magnitude of physiological disturbances.

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**TO FIT OR NOT TO FIT? – DETERMINATION OF THE LACTATE MINIMUM IN A LACTATE MINIMUM TEST IN ROWING**

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**INTRODUCTION:**

The lactate minimum test (LMT) was found to be a valid and reliable testing concept in rowing which allows the assessment of peak oxygen uptake (VO<sub>2</sub>peak), maximal lactate steady state (MLSS) and prediction of 2000m ergometer race performance based on one single test. [1] So far, in daily practice the lactate minimum (LM) was determined by optically identifying the nadir of the lactate curve. However, a study by Dotan et al. [2] reasoned that curve fitting provides a better estimation of MLSS based on LM data. The aim of the present investigation was to compare the conventional method for LM determination in rowing with the exact mathematical determination by means of curve fitting.

**METHODS:**

20 healthy male rowers (age 22.8±6.7y, height 185.9±5.2cm; body mass 78.3±8.1kg; VO<sub>2</sub>peak 65.6±6.5ml/min/kg) performed a LMT on a rowing ergometer according to the test procedure proposed by Perret and Vrana. [1] Power output and heart rate at LM were determined by analyzing the corresponding lactate curve by two different methods: i) conventional optical analysis (NON-FIT) and ii) mathematical analysis applying a polynomial of degree 3 (FIT). Bland-Altman plots were used for analyzing the agreement of parameters at LM between NON-FIT vs. FIT to assess whether one method is substitutable by another. Further, Spearman correlations were performed to determine the degree of association between data of NON-FIT vs. FIT.

**RESULTS:**

Power output (r<sup>2</sup>=0.942; p<0.001) and heart rate (r<sup>2</sup>=0.937; p<0.001) at LM showed a high correlation between NON-FIT and FIT. Bland-Altman plots revealed that all values were within the limits of agreement (power output bias=-6±7W; heart rate bias=0±2bpm).

**CONCLUSION:**

This finding shows that for a correct determination of the LM data with the applied rowing protocol, curve fitting is not necessary. Therefore, this testing procedure provides reliable results based on a simple optical analysis.

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## OP-AP02 Warm-up and Recovery

### INTERMITTENT PNEUMATIC COMPRESSION EFFECT ON THE BEHAVIOR OF THE CENTER OF PRESSURE AND MUSCLE PAIN

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#### INTRODUCTION:

Intermittent Pneumatic Compression (IPC) is applied by elite athletes to improve the recovery of muscular fatigue (1, 2). The recovery process is essential to anticipate athlete's return to training, improving the specific adaptations to it and reducing the risk of injury. The purpose of our study was to assess the effectiveness of IPC on the balance and muscle pain as parameters of muscular fatigue, after an eccentric exercise.

#### METHODS:

We conducted a crossover single-blinded study in which twenty-five subjects (18 ♂ 7 ♀) performed a fatigue-inducing exercise (10 x10 drop jump). After that, they received three IPC sessions or simulation (control group) of 40 minutes each, on consecutive days and during which values of the baropodometry tests (stabilometry, Sway and dynamic gait) and pressure pain threshold (PPT) were collected. Differences, were analyzed by means of a repeated measures analysis (ANOVA).

#### RESULTS:

For the stabilometry a main effect of the type of treatment was found in the three variables studied: mean pressure of the left and right foot ( $F(1, 17) = 41.765, \eta^2 = 0.711, p < 0.001$  /  $F(1, 17) = 30.14, \eta^2 = 0.63, p < 0.001$ ), percentage of load of the left and right forefoot ( $F(1.17) = 10.6, \eta^2 = .38, p = .005$  /  $F(1.17) = 17.69, \eta^2 = .51, p = .001$ ) and load percentage of the left and right hindfoot ( $F(1.17) = 9.55, \eta^2 = .36, p = .007$  /  $F(1.17) = 14.57, \eta^2 = .46, p = .001$ ). Also, in the bipodal sway there was a main effect of the treatment on the variables of length ( $F(1.16) = 15.53, \eta^2 = .49, p = .001$ ), area ( $F(1.16) = 7.92, \eta^2 = .33, p = .012$ ), Delta X ( $F(1.15) = 12.14, \eta^2 = .44, p = .003$ ), Delta Y ( $F(1.16) = 12.59, \eta^2 = .44, p = .003$ ), average speed ( $F(1.16) = 17.01, \eta^2 = .51, p = .001$ ), RMS ( $F(1.16) = 20.53, \eta^2 = .56, p < .001$ ), RMSX ( $F(1.16) = 10.85, \eta^2 = .40, p = .005$ ) and RMSY ( $F(1.16) = 20.86, \eta^2 = .56, p < .001$ ). There was no main effect of the type of treatment, or of time, or of its interaction (treatment x time) for any of the variables studied. Finally, a significant effect of time for PPT was found ( $F(3.18, 31.82) = 4.79, \eta^2 = .32, p = .006$ ).

#### CONCLUSION:

There were no significant differences on the balance or pain between groups which means that there was little additional benefit associated on the use of IPC to enhance recovery. Because of that, more studies are needed to confirm its use among athletes after heavy training sessions.

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### DOES A SELF-SELECTED WARM-UP IMPROVE 500M SPRINT KAYAK PERFORMANCE IN NATIONAL AND INTERNATIONAL LEVEL ATHLETES?

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#### INTRODUCTION:

Completing a warm up (WU) prior to exercise is essential in enhancing athletic performance yet, no studies have examined WU procedures over 500m sprint kayak performance. Therefore, this study sought to determine if a self-selected (SS) WU enhanced 500m kayak performance compared to continuous (CON) and intermittent high intensity (IHI) type WU.

#### METHODS:

Twelve national and international level sprint kayakers (age  $17.7 \pm 2.3$ -y, mass  $69.2 \pm 10.8$ -kg, stature  $176.8 \pm 7.4$ -cm) attended the laboratory for testing on four occasions. On the first occasion participants performed a graded exercise test until volitional exhaustion to determine the watts at lactate threshold (2 m-mol-1; LT) and VO<sub>2</sub>max. In subsequent visits participants performed a CON WU (15 minutes at LT), a IHI WU (10 minutes at LT, followed by 5 x 10s sprints at 200% wattage at VO<sub>2</sub>max with 50s recovery at 55% wattage at VO<sub>2</sub>max and SS (athlete's normal competition) WU in a randomised order. WUs were followed by a five-minute passive recovery and a 500m time trial (TT). All WU and TT performances were completed on a kayak ergometer. Heart rate (HR) and blood lactate (BLa) were recorded five minutes prior to and one minute after the WU and again one-minute prior and one-minute post TT performance. Ratings of perceived exertion (RPE) was recorded at the end of the WU and TT.

#### RESULTS:

An interaction effect was observed for BLa and RPE ( $P < 0.05$ ). After the WU, BLa and HR increased to a greater extent in the CON ( $ES = 0.20$  and  $0.79$ , respectively) and IHI ( $ES = 0.92$  and  $0.79$ , respectively) trials than the SS trial. RPE post WU was greater in the CON and IHI trials than SS ( $ES = 1.04$  and  $1.64$ , respectively). TT performance was significantly lower ( $P < 0.05$ ) in the SS trial ( $125.7 \pm 12.2$  s) compared to CON ( $128.0 \pm 14.6$  s, effect size ( $ES$ ) =  $0.18$ ) and IHI ( $128.2 \pm 13.31$  s;  $ES = 0.20$ ) trials. The increase in BLa after the TT was greater during the SS trial than CON ( $ES = 0.49$ ) whereas there were no differences between SS and IHI conditions ( $ES = 0.09$ ). HR was greater after the TT in both CON and IHI conditions than SS ( $ES = 0.25$  and  $0.66$ , respectively). After the TT, RPE was greater in the SS condition than CON and IHI conditions ( $ES = 0.20$  and  $0.59$ , respectively).

#### CONCLUSION:

This is the first study to compare WU strategies over 500m in national and international level sprint kayakers. We report that SS WU provided greater benefits on 500m TT performance compared to CON and IHI WUs. That HR, BLa and RPE were all lower during the WU in the SS trial than CON and IHI WUs, might suggest that athletes are able to auto-regulate their intensity and effort in the WU before competition. Practically, we recommend that national and international level sprint kayakers adopt an individualised WU strategy before sprint competitions.

### IMPACT OF RECOVERY PRACTICES ADOPTED BY ELITE TENNIS PLAYERS ACCORDING TO TRAINING TYPE CLUSTERS DURING PREPARATION AND PRE-COMPETITIVE PHASES

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#### INTRODUCTION:

An accurate quantification of training load, exercise-induced fatigue together with the impact of recovery techniques implemented in tennis practice become essential to face congested schedules imposed to modern elite players. The present study aimed to determine training type clusters and recovery practices adopted by elite tennis players in ecological training conditions. The respective impact of training type clusters and recovery techniques on subjective variables reflecting perceptual recovery were subsequently determined

#### METHODS:

During 15 consecutive months, thirty-six elite tennis players filled out questionnaires informing about daily training load (sRPE), training sessions content, recovery modalities adopted after training. Immediately after training and just before recovery, players were asked to score the three following subjective variables: muscle soreness, stress, perceived fatigue. The next morning and before training, players filled out the three same variables completed by two additional factors: sleep quality and perceived recovery

#### RESULTS:

Hierarchical analysis identified three training type clusters. Cluster 1 (sRPE :1058 ± 319 U.A), Cluster 2 (sRPE :1427 ± 377 U.A) and Cluster 3 (sRPE :1728 ± 520 U.A) did not show any differences on muscle soreness and perceived fatigue neither before nor after recovery intervention ( $p = 0.07$  to  $0.65$ ). Over the 146 recorded training and recovery sessions, players mainly employed a combination of two or three modalities with cooling strategies being the most widely used techniques (87.6%). Mixed linear models revealed that, independently of training clusters, cooling strategies significantly decreased muscle soreness ( $-0.99 \pm 0.42$ ,  $p = 0.0208$ ). Among cooling techniques, whole-body cryotherapy induced a greater perceived recovery compared to cold-water immersion ( $p = 0.02$ ).

#### CONCLUSION:

The present results show that perceptual recovery was not sensitive to training clusters and associated acute training load. Future research should investigate the potential impact of accumulated training load on longer periods of time. The benefits of recovery routines comprising multiple techniques seem to be well anchored in practice. During preparation phase and pre-competitive period, cold modalities appear efficient to decrease tennis training-induced muscle soreness compared to other recovery techniques. This work is a first step towards a periodized, and individualized approach of recovery interventions based on the interactions between training load, training content and perceptual recovery.

### SELF-SELECTING THE NUMBER OF REPETITIONS IN POTENTIATION PROTOCOLS ENHANCES JUMPING PERFORMANCE

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#### INTRODUCTION:

A growing number of studies investigated protocols designed to optimise post-activation potentiation enhancements (PAPE) effects by manipulating PAPE related variables. However, the vast majority of them are commonly designed using predetermined and non-personalized loads and volumes. One viable strategy to individualise the volume in the conditioning activity of PAPE protocols is by allowing participants to choose when to terminate a set. Allowing people to act autonomously by making choices is an evidence based powerful coaching strategy. In view of the accumulating evidence, investigating if choicer provision strategy can be implemented in PAPE protocols is a worthwhile endeavour. Therefore, the aim of this study was to investigate if providing athletes with a choice regarding the number of repetitions to complete in a potentiation protocol would enhance jumping performance compared to protocols in which the number of repetitions is predetermined.

#### METHODS:

Fifteen male basketball players completed four testing sessions separated by 72 hours. On the first session, individual optimum power loads (OPL) in the barbell jump squat were determined. On the following three sessions, athletes completed three sets of three potentiation protocols using OPL jump squats in a partly-randomized order: i) traditional condition included six repetitions per set; ii) self-selected condition included a choice regarding the number of repetition to complete per set; iii) imposed condition included the same number of repetitions per set as the self-selected condition but imposed on the athletes beforehand. Jumping performance was measured using a force platform before, 30s, 4-min, and 8-min after completing the protocols.

#### RESULTS:

The self-selected condition led to superior jumping performance compared to the two other conditions across all post measures ( $p < 0.05$ ; range: 0.3-1.3 cm). Compared to the traditional condition, the imposed condition led to superior jumping performance across all post measures (range: 0.2-0.45 cm) although not statistically significant at post 4 and 8-min.

#### CONCLUSION:

Choice provision concerning how many repetitions to complete in a potentiation protocol is a useful performance enhancing strategy. Improved potentiation-fatigue ratio and motivational factors are sought to explain these effects. Coaches should consider granting athletes with individual choices about the training volumes to be used for PAPE protocols aimed at enhancing vertical jump performance. Choice provision seems to exploit the PAPE effects by increasing the motivational drive, by reducing fatigue and by enhancing the mechanical responses underpinning jumping performance. In view of the performance augmentations observed in this study coupled with the broad supporting research, choice provision coaching strategies should likely be used more often and more explicitly by strength and conditioning coaches.

### THE EFFECTS OF ACTIVE RECOVERY USED ON THE NEXT DAY AFTER A HIGH-INTENSITY EXERCISE SESSION ON FATIGUE MARKERS: A DOUBLE CROSS-OVER STUDY

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#### INTRODUCTION:

The purpose of this double cross-over trial was to identify if active recovery (ACT) used on the next day after a high-intensity exercise session benefits recovery and to assess whether individual re-sponses are replicable over multiple recoveries.



### METHODS:

After an initial familiarization and pre-examination, 11 well-trained male intermittent sport athletes (age:  $25.5 \pm 1.8$  years) completed 4 intensive exercise sessions, separated by 2-week washout periods. Each was followed by either passive recovery (PAS) or 60 min of moderate biking (ACT) 24 h after the fatiguing activity in the following order: ACT, PAS, ACT, PAS or PAS, ACT, PAS, ACT. Maximal voluntary isometric strength (MVIC), countermovement jump (CMJ) height, muscle contractile properties, serum concentration of creatine kinase, perception muscle soreness, and perceived recovery and stress states were determined before and after training as well as after 24 h and 48 h of recovery. Values were analysed using a full factorial three-way ANOVA employing three main factors of recovery intervention (RI; two levels: ACT and PAS), sequence (two levels: two times ACT vs. PAS), and time (four levels). Individual random effects of inter-time, -sequence, and individual were nested within intervention to control for unobserved heterogeneity. Significant effects ( $p < 0.05$ ) were further evaluated with a Tukey's multiple comparison procedure.

### RESULTS:

All parameters revealed a significant time effect, and post hoc analyses indicated that training always induced a similar temporary state of fatigue. Effects on RI were never significant, suggesting that ACT did not affect exercise-induced fatigue. Sequence effects were only significant for MVIC and CMJ height, but absolute differences were small, suggesting that athletes responded similarly in both cross-over. The distribution of variance components among the random effects indicated that the variability of data between sequences is similar, further suggesting that athletes' response is not altered between the first and second cross-over.

### CONCLUSION:

Overall, a consistent inability of ACT to limit the severity of fatigue was found. Thus, athletes and their coaches are advised to focus on other recovery modalities rather than ACT. However, since ACT was not detrimental to the recovery process, individual preferences, experiences and beliefs may influence the choice of whether ACT is performed as a recovery method.

## OP-AP03 High intensity training

### NON-INVASIVE EVALUATION OF THE TIME-COURSE CHANGES IN PHYSIOLOGICAL ADAPTATIONS TO LOW-VOLUME HIGH-INTENSITY INTERVAL TRAINING

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#### INTRODUCTION:

High-intensity interval training (HIIT) is one of the most effective interventions in improving cardiorespiratory and metabolic functions in short-term periods. HIIT protocols elicit improvements in maximal oxygen consumption due to both central (e.g. cardiac output and blood volume) and peripheral (e.g. capillary density and mitochondrial function) adaptations. The relative contribution of these factors seems to be affected by several factors including the duration of the training intervention. The aim of this study was to evaluate by non-invasive methods the time-course changes of physiological adaptations at central and peripheral level during 8 weeks of low-volume HIIT.

#### METHODS:

Thirteen healthy subjects (age:  $29 \pm 5$  ys,  $\dot{V}O_{2peak}$ :  $35.2 \pm 5.8$  ml/min/kg), who had never been involved before in structured training programs, performed 24 sessions of low-volume HIIT over 8 weeks. Each subject attended the laboratory at baseline (T0), after 4 weeks (T4) and at the end of the training period (T8). After a brief leg-extension exercise, repeated transient arterial occlusions were carried out by a rapid cuff inflator at the level of femoral artery. Slope changes in tissue saturation index obtained by near infra-red spectroscopy positioned on the vastus lateralis muscle were utilized for non-invasive determination of the muscle oxygen consumption ( $m\dot{V}O_2$ ) recovery rate constant (k), which is proportional to ex-vivo mitochondrial function. During an incremental exercise test on a cycle ergometer, pulmonary ventilation ( $\dot{V}E$ ), oxygen consumption ( $\dot{V}O_2$ ), and  $CO_2$  output ( $\dot{V}CO_2$ ) were determined breath-by-breath by a metabolic cart. Heart rate (HR), stroke volume (SV) and cardiac output (Q) were monitored by transthoracic impedance.

#### RESULTS:

Results are referred to seven subjects who have already completed the entire training protocol.  $\dot{V}O_{2peak}$  significantly increased across the 8 weeks period ( $2.333 \pm 0.468$ ,  $2.605 \pm 0.512$ ,  $2.677 \pm 0.457$  L/min in T0, T4 and T8 respectively).  $Q_{peak}$  was  $18.1 \pm 3.4$  L/min at T0 and it showed a similar magnitude of change (about 7%) at both T4 ( $18.7 \pm 2.3$  L/min) and T8 ( $20.1 \pm 2.6$  L/min). K values for  $m\dot{V}O_2$  were  $1.65 \pm 0.58$ ,  $1.73 \pm 0.53$  and  $2.24 \pm 0.91$  min<sup>-1</sup>, in T0, T4 and T8, respectively. The magnitude of change between T0 and T4 ( $6.5 \pm 5.7\%$ , mean  $\pm$  SEM) resulted significantly lower than that observed between T4 and T8 ( $26.9 \pm 7.16\%$ , mean  $\pm$  SEM,  $p < 0.05$ ).

#### CONCLUSION:

In young sedentary subjects, eight weeks of low-volume high-intensity interval training significantly improved  $\dot{V}O_{2peak}$  due to both central and peripheral physiological adaptations. Interestingly, the magnitude of changes in muscle oxidative capacity estimated by near infra-red spectroscopy resulted higher in the second part of training. Thus, changes in intrinsic metabolic adaptations of skeletal muscle seems to be delayed compared to central adaptations when sedentary subjects are exposed to a primary high-intensity interval training stimulus.

### ENERGY MATCHING OF A HIGH INTENSITY EXERCISE PROTOCOL WITH A LOW INTENSITY EXERCISE PROTOCOL IN ADOLESCENTS

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#### INTRODUCTION:

Prior to undertaking the feasibility and main trial for a National Institute for Health Research funded project called READY, the protocol for the exercise intervention needed to be pilot tested. To ensure efficient comparison between high and low intensity exercise protocols they need to be energy matched to ensure any differences in results between groups is a consequence of the type of exercise and not the quantity of exercise. Therefore, this pilot testing aimed to match the energy expenditure in the low and high intensity exercise interventions using indirect calorimetry.

#### METHODS:

Healthy adolescents (n=14 boys, n=9 girls, 15±2yrs, height 168.1±11.1cm, weight 57.9±15.2kg) volunteered to take part in this study. After fasting for 2 hours participants attended the sports science laboratory on one occasion. They walked for 5 min at a comfortable walking speed on a treadmill determined depending on their height (<165cm they walked at 4 km.hr<sup>-1</sup>, >165cm they walked at 4.5 km.hr<sup>-1</sup>). Following this, they completed the low intensity exercise (LIE) protocol for 10 min which was simulated walking football. The participants walked between 2 cones placed 14m apart. Every 4th repetition they dribbled the football and kicked it at 70-degree angle at the end of the 14m. Once heart rate (HR) had returned to baseline, they completed the high intensity interval exercise (HIIE) protocol. This included 45s of high intensity boxing exercises followed by 90s of rest. This was repeated 4 times (total duration of 9 minutes). An average HR (bpm) was recorded for each activity. Gas analysis was recorded throughout all exercise using a portable online breath by breath analyser to calculate energy expenditure (EE) for each activity. Total EE was calculated from the expired gases of the HIIE protocol using equations from Jeukendrup & Wallis (2005) for high intensity exercise. Then an average EE for one minute for the LIE was calculated. From this, the duration needed in minutes for the LIE to match the HIE was calculated.

## RESULTS:

To energy match 9 minutes of HIIE, 11.9±1.9 minutes of LIE is required. EE per min for walking, LIE and HIIE respectively was 3.4±0.7, 4.0±0.7 and 6.2±1.7 kcal. The exercise intensity was similar between treadmill walking (54±8% HRmax) and LIE (59±8% HRmax) whereas HIIE produced a higher heart rate of 82 ±7%HRmax.

## CONCLUSION:

As can be seen from the results for 9 minutes of HIIE, approximately 12 minutes of LIE is needed. It must be noted that the HIIE is equivalent to 3 minutes of actual exercise along with 6 minutes of rest whereas the LIE is continuous exercise for 12 minutes. When designing the READY exercise intervention, the LIE duration needs to be 133% that of the total HIIE protocol duration.

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### TIME-MATCHED ECCENTRIC VS. CONCENTRIC MODIFIED SPRINT INTERVAL TRAINING SESSIONS AND THEIR EFFECTS ON JUMP POTENTIATION

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## INTRODUCTION:

Eccentric (ECC) cycling has become an important exercise alternative in recent years. In addition, modified sprint interval training (SIT) consisting of short sessions with completion of very short (≤10 s) sprints, has been suggested to be more efficient than traditional SIT of longer durations. However, there are no studies comparing concentric (CON) vs. ECC SIT sessions. Meanwhile, recent evidence has suggested the greater efficacy of ECC overload in different resistance exercises for jump potentiation. However, it is not clear if this advantage would be evident after ECC vs. CON cycling with varying levels of potentiation and inhibition of different origin. Therefore, the purposes of this study were: 1) to describe and compare the physiological and mechanical responses of two ECC vs. CON time-matched modified (5 s) SIT protocols; and 2) to compare the acute effects of these protocols on jump potentiation. It was hypothesized that ECC SIT would exhibit lower metabolic responses and a lower jump potentiation than CON SIT.

## METHODS:

Nine endurance-trained young men (24.1 ± 3.0 years, 184 ± 7 cm, 77.1 ± 7.6 kg, 9.7 ± 1.9% bodyfat, VO<sub>2</sub>max 66 ± 6 ml/min/kg) were enrolled in this randomized controlled crossover trial. After two familiarization sessions, participants underwent two modified SIT sessions of either ECC or CON cycling SIT. The SIT protocols consisted of 2 min warm up with 80 rpm at 75 W, followed by 8 sprints of 5 s, interspersed with 55 s of active recovery (80 rpm at 75 W). Each sprint bout was instructed as "all out" in CON SIT, while in ECC SIT participants had to brake with maximal effort against the backward crank movement at 80 rpm. Heart rate (HR) and power were continuously recorded, while peak blood lactate (LA<sub>peak</sub>) was assessed after the loadings. Before (after warming up) and immediately after both protocols, counter-movement jump (CMJ) was assessed with a force plate at 500 Hz.

## RESULTS:

Mean HR (131 ± 13 vs. 97 ± 14 bpm), peak power (1,164 ± 112 vs. 821 ± 78 W), mean power (140 ± 9 vs. 109 ± 21 W), and LA<sub>peak</sub> (5.4 ± 2.5 vs. 1.7 ± 0.4 mMol/L) were statistically (p = 0.000) greater in CON than in ECC SIT. A statistical interaction was observed for jumping height (p = 0.03, eta-squared = 0.57). Subsequent pairwise post hoc testing revealed a statistical improvement in jumping height after CON (pre: 32.4 ± 5.9 cm to post: 34.9 ± 5.6 cm, p < 0.001) but not after ECC SIT (pre: 31.4 ± 6.1 cm to post: 32.1 ± 5.5 cm, p = 0.24).

## CONCLUSION:

The CON SIT 10-min protocol exhibited greater metabolic and mechanical responses than a time-matched ECC SIT protocol. Jump potentiation occurred only after CON cycling SIT therefore suggesting a more favorable potentiation/inhibition balance in endurance-trained young men.

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### INTERVENTION EFFECTS OF A HIGH-INTENSITY INTERVAL TRAINING ON PHYSICAL FITNESS AND BODY COMPOSITION IN ELITE ARTISTIC SWIMMERS

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## INTRODUCTION:

Previous research showed that high-intensity interval training (HIIT) could effectively improve participants' cardiopulmonary fitness. But few study explored its effects on elite athlete's physical fitness and body composition. Therefore, this study designed two sets of tailored training programs for improving the performance of specific competitions and to test the intervention effects of such training in elite artistic swimmers.

**METHODS:**

A sample of 15 elite artistic swimmers (100% female, mean age 22.71±2.86 y, height 169.1±2.72 cm, and body mass 52.85±2.66 kg) was recruited, including 11 international level and four national level athletes. The intervention was designed based on the needs of artistic swimmers to participate in a set of competition routine. Two types of HIIT training programs was developed: 1) basic strength training, and 2) strength endurance. All the participants received the intervention three times per week (Monday, Wednesday, and Friday), each for 90 minutes over five weeks. A total of 12 indicators (body fat percentage and 11 physical fitness tests, details shown in the results) were tested at baseline and after intervention. Paired t-test by SPSS was performed to test the intervention effects.

**RESULTS:**

The participants showed significant improvements in five physical fitness indicators after intervention: an average increase of 33.81W in the rotational upward pull force of the whole body ( $p<0.01$ ), 10.02s in the abdominal muscle endurance ( $p<0.01$ ), 2.61cm in the vertical jump (arm-free) ( $p<0.05$ ), 14.39W in the core rotation explosive force ( $p<0.05$ ), and 11.01s in the dorsal muscle endurance ( $p<0.05$ ). With respect to the other six physical fitness indicators, the trends of improvements were presented even without significant statistics: an increased by 1.44cm in the vertical jump (on-hip), 10.12W in the push press explosive force, 158.83W in the lat pull down explosive force, 2.59 times in the chin-ups, 0.05/1 minute in the 1 minutes double leg V up, and 15.73m in 5\*30s climbing machine height. The body fat percentage decreased by 0.71% at post-intervention compared with the baseline.

**CONCLUSION:**

A five-week HIIT could effectively improve the performance of elite artistic swimmers in some aspects of physical fitness. However, due to the limited sample size and individual differences, standard deviations of some indicators were large, which may result in the non-significant differences in other physical fitness indicators. Future studies could add the correlation analyses between these physical fitness and score of athletes' special technical difficulty test, to further verify the effectiveness of HIIT training.

**PERFORMANCE AND PHYSIOLOGICAL CHANGES FOLLOWING TWO TYPES OF INTERVAL TRAINING IN TRAINED KAYAKERS**

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**INTRODUCTION:**

Recent data suggests that peripheral adaptations, i.e. the muscle ability to extract and use oxygen, may be a stronger predictor of sprint kayak performance compared to central adaptations or even  $VO_{2max}$ . While short-interval training (S-HIIT) improves endurance performance particularly through central adaptations, performance improvement from sprint interval training (SIT) mainly comes from peripheral adaptations. Therefore, the purpose of this study was to assess the performance change and physiological adaptations following 9 sessions of S-HIIT or SIT in sub-elite kayakers and determine the most optimal approach.

**METHODS:**

Twelve well-trained kayak athletes performed an incremental test and 2 time-trials (200m and 1000m) on a kayak ergometer. Oxygen consumption ( $VO_2$ ), heart rate (HR) and muscle oxygenation of the latissimus dorsi (LD), biceps brachii (BB), and vastus lateralis (VL) were measured using portable near-infrared spectroscopy monitors in every session. Athletes were then randomized into a S-HIIT ( $n=6$ ) or a SIT training group ( $n=6$ ). Each group performed 9 interval training sessions over 4 weeks, and were tested again after a short taper (3-4 days). S-HIIT performed 2 to 3 sets of 20 x 15sec or 10 x 30sec at 110% maximal aerobic power (MAP) with recovery bouts of 15 or 30sec at 40%MAP. SIT performed 4 to 8 maximal efforts of 150 or 200m (30-45sec), with 5min of passive recovery between sprints. Paired t-test were used to assess the effect of training within each group and Pearson correlations were calculated to assess associations between physiological changes and performance improvements in each group.

**RESULTS:**

12±16sec, range -14 to +2 sec,  $p=0.13$ ; SIT: -2±8sec, range -10 to +12sec,  $p=0.566$ ), but increased in the 200m in S-HIIT (-2±1sec, range -3 to +1 sec,  $p=0.05$ ), but not in SIT (0±2sec, range -2 to +1sec). The improvement in 1000m performance was related to an improved minimum power ( $r=0.971$ ,  $p<0.01$ ) in S-HIIT, while it was related to an improved peak power in SIT ( $r=0.849$ ,  $p=0.03$ ). Improvement in the 1000m after S-HIIT was also related to increased  $VO_{2peak}$  ( $r=0.849$ ,  $p=0.03$ ) and to a decreased  $SmO_2$  in the LD muscle ( $r=-0.762$ ,  $p=0.08$ ). Improvement in the 200m performance tended to be related to an increase in LD  $SmO_2$  in the 200m after S-HIIT ( $r=0.812$ ,  $p=0.09$ ), but not SIT. In the 200m, the training-related change in  $VO_{2peak}$  was different between groups (S-HIIT: +3.1±5 ml/kg/min, SIT: -2.4±2.2 ml/kg/min,  $p=0.02$ ).

**CONCLUSION:**

We concluded that in a group of trained kayakers, greater improvements in performance can be obtained with S-HIIT and may be related to both central and peripheral adaptations. On the other hand, SIT did not improve performance and induced a highly variable response between subjects. Therefore, S-HIIT seems to be more beneficial to improve physiological responses and performance in sub-elite kayakers.

**ACUTE PHYSIOLOGICAL EFFECTS OF THREE COMPARABLE TRAINING PROTOCOLS APPLIED ON REAL-WORLD CONDITIONS**

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**INTRODUCTION:**

Recent meta-analysis confirmed that high intensity interval training (HIIT) is an essential strategy to improve health(1). However, most studies that proved the benefits of HIIT against other training modalities employed very dissimilar load-parameters (i.e. volume, intensity, workload, etc.) and were carried on in laboratory-environments(2). Therefore, the aim of this study is to compare the responses of three low-volume intense exercise approaches [HIIT, sprint interval training (SIT), intense continuous training (ICT)] under real-world conditions applying matched external/internal load.

**METHODS:**

10 adults (age:25.9±5.6yr; Body fat:18.9±7.6%;  $VO_{2max}$ :50.9±5.4ml·kg<sup>-1</sup>·min<sup>-1</sup>) participated in this study. They completed one session of physical/morphological assessment and familiarization with the exercise approaches. Next, three sessions with a crossover design were performed separated by 7 days. The intense exercise protocols with same volume were randomly accomplished on an official public running track during spring (18-25°Ctemperature, 40%humidity, 20km·hwind): SIT5s (14×5s with 35s of passive-recovery), HIIT15s [18×15s at 90% heart rate (HR) max with 15s of passive-recovery] and ICT (8min45s at 85%HRmax). During sessions we recorded: per-distance,

%HRmax, time $\leq$ 80%HRmax, time $\leq$ 90%HRmax, energy expenditure (EE) (Firstbeat), post-OMNI, feeling scale (FS), physical activity enjoyment scale (PACES), pre-vs.-post HR variability (HRV), lactate (LA) and countermovement jump (CMJ) (PUSH). Comparisons were made applying a one-way/two-way ANOVA-repeated measures with Bonferroni's adjustment. When normality was not corroborated non-parametric analysis was conducted.  $p < 0.05$ .

#### RESULTS:

Firstly, the distance was minor ( $p < 0.001$ ) in SIT5s and HIIT15s than ICT (429 $\pm$ 27vs.1318 $\pm$ 113vs. 1784 $\pm$ 193m). The %HRmax was lower ( $p \leq 0.001$ ) in SIT5s than HIIT15s and ICT (83.1 $\pm$ 2.9vs.87.6 $\pm$ 1.7vs.86.4 $\pm$ 2.5%). The time $\leq$ 90%HRmax was longer ( $p = 0.033$ ) in HIIT15s than SIT5s (180 $\pm$ 141vs.30 $\pm$ 58s), without differences for time $\leq$ 80%HRmax ( $p > 0.05$ ). No differences were found between protocols in EE ( $p > 0.05$ ). Additionally, OMNI (7.8 $\pm$ 1.3vs.7.3 $\pm$ 0.9vs.4.3 $\pm$ 1.5;  $p < 0.001$ ) resulted in higher values while FS (-0.6 $\pm$ 1.7vs.0.8 $\pm$ 2.6vs.3.2 $\pm$ 1.5;  $p = 0.003$ ) exhibited lower values for HIIT15s and SIT5s in comparison to ICT. No differences were found between protocols in PACES ( $p > 0.05$ ). Finally, significant interaction effects were identified in LA ( $p < 0.001$ ) being higher post-trainings for HIIT15s and SIT5s than ICT (10.6 $\pm$ 3.7vs.11.5 $\pm$ 3.4vs.5.4 $\pm$ 1.7mmol $\cdot$ L $^{-1}$ ). For RMSSD (HRV) and CMJ no interaction was detected ( $p > 0.05$ ).

#### CONCLUSION:

HIIT15s maintained a longest time inside the "red zone" which is considered as a key factor to induce cardiorespiratory adaptations(3). Moreover, glycolytic demand and psychological response were higher during HIIT15s and SIT5s without differences in acute fatigue between approaches.

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## OP-AP04 Fatigue

### ISOKINETIC AND EMG RESPONSES TO DIFFERENT LOADING CONDITIONS DURING RESISTED SPRINT TRAINING

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#### INTRODUCTION:

Resisted sprint training is an effective method for the development of sprint performance (Alcaraz et al., 2018; Bachero-Mena et al., 2014). When short sprints at maximal intensity are repeated during training sessions, fatigue may occur, which has been described as any exercise-induced reduction in the maximal voluntary force or power produced by a muscle (Gandevia, 2001). Surface EMG is a valuable technique for evaluating muscle activation and fatigue. The purpose of this study was to explore the acute effects of sled towing with a wide range of loads (from unloaded to 80% body mass) on EMG responses during isokinetic knee extension.

#### METHODS:

Twelve male participants performed 8 x 20-m sprints with 2-min rest with 5 different loading conditions (0%, 20%, 40%, 60%, and 80% body mass). Subjects were randomly assigned to perform the same sprint training protocol in 5 different loading conditions during 5 sessions separated by 1 week. Subjects performed isokinetic (Biodex System 4, NY) knee extension contraction at an angular velocity of 60° s $^{-1}$  (isokinetic data for Peak torque and Mean Power were obtained), while EMG signals (Mdurance System, Spain) from vastus lateralis (VL) and vastus medialis (VM) were recorded at 3 different time-points (pre-exercise [PRE], post-exercise [POST], and 24-hour post-exercise [POST24H]). The EMG data (RMS values) were normalized to those obtained during pre-exercise maximal knee extension contraction of each muscle (%EMGpre). A 5x3 repeated-measures analysis of variances was calculated with Bonferroni post hoc adjustments. Statistical significance was established at  $p < 0.05$ .

#### RESULTS:

No differences between loading conditions were found neither in EMG responses nor in isokinetic Peak and Mean Power. Significant decreases in VL-EMG from PRE to POST tests were found for 40% loading ( $p < 0.05$ ), and significant increases in EMG responses for the same muscle from POST to POST24H were observed for 0% loading ( $p < 0.05$ ). As regards the VM-EMG responses, significant increases in the 80% loading condition from POST to POST24H tests were observed ( $p < 0.05$ ). No significant differences with PRE were observed for the isokinetic measures at POST and POST24H for any of the loading conditions.

#### CONCLUSION:

After a sprint training protocol (8x20-m) performed in different loading conditions, the 40% condition showed significant decreases in VL-EMG values from PRE to POST, although these decreases were not accompanied by changes in Peak or Mean Power values. Moreover, increased EMG responses were observed at POST24H for 0% in VL and for 80% in VM with respect to POST. This tendency was observed in all the groups, showing that at 24h, EMG responses returned to initial values, and even to values higher than those observed in PRE for 0%, 20%, and 80% in VL and for 20%, 60% and 80% in VM. This result may suggest a possible effect of potentiation at 24h in the muscle excitations after the sprint training protocol performed with those loads.

### MENTAL FATIGUE REDUCES TACKLE TECHNIQUE PROFICIENCY IN RUGBY UNION PLAYERS

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#### INTRODUCTION:

Proficient tackle technique in rugby union has been associated with a reduced risk of injury and higher likelihood of tackle success. Tackle technique proficiency has been shown to decrease in the second half of matches. These findings suggest that fatigue may influence tackle technique. In football, mental fatigue has been shown to reduce the technical ability of players. However, no study to date has tested the effect of mental fatigue on tackling technique in rugby union players. To develop better injury prevention and performance strategies, a better understanding of the effect of mental fatigue on tackle technique is required. Therefore, the purpose of this study was to determine the effect of mental fatigue on tackle technique in rugby union players.

#### METHODS:

Twenty (n=20) rugby union players participated in a randomised cross-over study design with a mental fatigue condition and non-mental fatigue condition (control). During each condition, each player performed four sets of 6 tackles (set 1=baseline; 3 tackles on each shoulder)

on a contact simulator (945 tackles in total). Between each set of tackles in the mental fatigue condition, players performed the Stroop test. Between each set of tackles in the control condition, players passively rested for the same amount of time the Stroop test was administered. Each condition was separated by at least one week. Each tackle was video recorded and analysed using a standardised list of tackling technical criteria. The technical criteria outlines a list of observable actions, and a player is awarded either one point or zero depending on whether a particular action is performed or not. The sum of these points is subsequently used to represent the technical proficiency score of the player. Subjective ratings of physical and mental fatigue were also captured before and after each tackle set.

**RESULTS:**

For dominant and non-dominant shoulders combined, technique proficiency scores decreased significantly in the mental fatigue condition from baseline to set one, two and three (Baseline 7.4 [7.1-7.8] AU, vs set one 7.0 [6.6-7.4] AU,  $p=0.004$ ; vs set two 7.0 [6.6-7.4] AU,  $p=0.003$ ; vs set three 6.9 [6.5-7.3] AU,  $p=0.001$ ). For the non-dominant shoulder, significant differences were found between baseline and set three (Baseline 7.1 [6.7-7.5] AU; vs set three 6.6 [6.2-7.0] AU,  $p=0.02$ ). Differences between conditions were also observed at set two  $p=0.035$  and set three  $p=0.039$ ), whereas no significant differences were observed in the control condition.

**CONCLUSION:**

This study showed that mental fatigue had an effect on tackle technique in rugby union players. The effect of mental fatigue on tackling technique seemed to be more influential when tackling with the non-dominant shoulder. The findings of this study can be used to design and develop tackle training programmes to better prepare players for match tackle demands, with the ultimate goal of reducing the risk of injury while improving tackling performance.

**RELIABILITY AND MYOELECTRIC RESPONSE OF THE KNEE FLEXORS DURING THE SINGLE LEG BRIDGE TEST UNTIL EXHAUSTION IN HEALTHY PARTICIPANTS.**

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**INTRODUCTION:**

The single leg bridge test (SLBT) is an easy to use clinical field test for screening purposes in elite level athletes. This test is believed to provide relevant information regarding the athlete's readiness while returning to practice after an injury, in particular about the hamstring strength endurance. However, the semitendinosus and biceps femoris long head electromyography (EMG) responses during SLBT performed until exhaustion are still unknown. The present study examined the surface EMG signal amplitude and median frequency during SLBT until exhaustion. Additionally, we investigated the reliability of these EMG-related parameters.

**METHODS:**

Twelve physically active men (age:  $25\pm 6.3$  yrs; height:  $1.76\pm 0.07$  m; body mass:  $75.5\pm 8.3$  kg) with no previous history of hamstrings injury participated in this study. The experiment took place in two different days for inter-day reliability analysis purposes. EMG sensors were placed on the BFlh and ST guided by ultrasound imaging for a more appropriate alignment and orientation with the muscle fibers. An accelerometer was fixed with tape on the anterior aspect of the iliac crest to detect the different repetitions. Both EMG and accelerometer signals were recorded at 1 kHz. The test was performed at 1 cycle per second, by following a feedback sound beep from a metronome. After detecting the accelerometer events to define the different repetitions, the EMG median frequency and amplitude were calculated from each repetition on a 500ms window. Then, the mean value from the first three and last three repetitions were calculated for both frequency and amplitude parameters. A two-way repeated measures ANOVA was performed [2 sessions  $\times$  2 moments (start, end)] for each EMG outcome (i.e. amplitude, median frequency). This was conducted separately for BFlh and ST. Additionally, reliability analysis was performed by means of Intraclass Correlation Coefficient (ICC) and standard error of measurement (SEM).

**RESULTS:**

No interaction nor main effects for session were observed for both parameters from both muscles under investigation ( $p>0.05$ ). However, a significant main effect was observed for moment: BFlh ( $p=0.001$ ) and ST ( $p=0.039$ ) amplitude was higher, and the BFlh ( $p<0.001$ ) and ST ( $p<0.001$ ) median frequency was lower at the end of the task. A high inter-day reliability was observed for the number of repetitions (ICC<sub>2,1</sub>=0.85, SEM=4.10), and a low to very high inter-day reliability was found regarding the EMG-related outcomes (ICC<sub>2,1</sub>=0.39-0.91).

**CONCLUSION:**

The present study indicates that SLBT performed until failure induces EMG changes in ST and BFlh suggesting localized fatigue, and these responses are consistent between days. This strengthens the potential use of the SLBT as an on field functional screening test for hamstring muscles endurance.

**DOES SEX IMPACT THE PSYCHOPHYSIOLOGICAL RESPONSES TO INCREMENTAL EXERCISE FOLLOWING TRANSCRANIAL DIRECT CURRENT STIMULATION?**

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**INTRODUCTION:**

Transcranial direct current stimulation (tDCS) has emerged as a minimally invasive form of cortical stimulation, with exciting potential for exercise performance. However, it is unknown whether this simple technique has similar effects on exercise performance in men and women. This void in the literature is significant because sex differences in the modulation of human cortical plasticity have been well established by previous tDCS studies. We therefore investigated the effects of acute tDCS on exercise performance and psychophysiological responses to incremental exercise in men and women.

**METHODS:**

Recreationally trained men ( $n = 13$ ; mean  $\pm$  SD, age  $27 \pm 5$  yr, weight  $70 \pm 7$  kg, height  $176 \pm 7$  cm) and women ( $n = 12$ ; mean  $\pm$  SD, age  $30 \pm 5$  yr, weight  $58 \pm 4$  kg, height  $163 \pm 5$  cm) completed ramp incremental exercise tests from rest to volitional exhaustion, following 20-min of brain stimulation with either placebo tDCS (sham) or real tDCS (cathodal and anodal) applied over the primary motor cortex (M1) region. Pulmonary gas exchange and ventilation, and muscle oxygenation and hemodynamics data were collected continuously during the ramp exercise test. Ratings of perceived exertion (RPE) and affective valence in response to the ramp exercise test were also measured. One-factor, repeated-measures ANOVA was used for comparison of time to exhaustion between the different brain stimulation conditions

(sham, anodal tDCS, and cathodal tDCS) separately for both men and women. Two-way repeated-measures ANOVA was used for all other comparisons, using the brain stimulation conditions and time as main factors. A statistical level of  $p < 0.05$  was accepted.

**RESULTS:**

There was no significant effect of brain stimulation condition on time to exhaustion in either men or women ( $p > 0.05$ ). In men, the ramp exercise protocol lasted, on average,  $533 \pm 46$  s,  $537 \pm 40$  s, and  $530 \pm 44$  s in sham, cathodal tDCS, and anodal tDCS conditions, respectively, whereas in women the ramp exercise protocol lasted, on average,  $508 \pm 63$  s,  $506 \pm 65$  s, and  $504 \pm 70$  s in sham, cathodal tDCS, and anodal tDCS conditions, respectively. Compared with sham, neither anodal tDCS nor cathodal tDCS altered related physiological responses to incremental exercise in both men and women ( $p > 0.05$ ). Similarly, RPE and affective responses during the ramp exercise test did not differ between the three experimental conditions at any time, regardless of sex ( $p > 0.05$ ).

**CONCLUSION:**

Our findings demonstrate that acute tDCS applied over the m1 region did not impact exercise performance and psychophysiological responses to incremental exercise in healthy adults, regardless of sex. These results are therefore consistent with the notion that this simple noninvasive neuromodulatory technique is not effective to alter physiological responses, perception of effort, pleasant feelings, or exercise tolerance during activities requiring large muscle mass.

**THE RATE OF W' RECOVERY IS AFFECTED BY THE EXERCISE INTENSITY DOMAIN OF THE RECOVERY BOUT**

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**INTRODUCTION:**

The incorporation of  $W'$  recovery kinetics has extended the application of the critical power model to a wide range of intermittent activities. This study aimed to investigate the effect of recovery intensity (i.e., in the moderate and heavy intensity domain) on the  $W'$  recovery and as such on the predictive capabilities of the  $W'$ BAL model.

**METHODS:**

Twelve male participants ( $26 \pm 3$ yr,  $52 \pm 6$ mL•kg<sup>-1</sup>•min<sup>-1</sup>) completed three to five constant work rate tests to determine  $W'$  and CP which was followed by MLSS verification testing. During four randomized experimental trials subjects performed two work bouts (WB) at P6 (i.e. the intensity that predicts exhaustion in 6 min) separated by varying recovery intervals. WB1 was designed to deplete 75% of  $W'$  (i.e. 4.5 min) and recovery time was calculated to replenish 50% of  $W'$  (i.e.  $W'$ BAL= 75%) at different recovery intensities (MLSS-10W, MLSS-GET, GET, 50% GET). Thereafter subjects performed WB2 to exhaustion. The actual  $W'$  ( $W'$ ACT) available following the recovery conditions was calculated from the duration of WB2 (i.e., duration of WB2 expressed relative to the expected duration of P6: 6min). Reconstitution values of  $W'$  were expressed relative to resting  $W'$  (%).

**RESULTS:**

$W'$ ACT differed significantly between conditions ( $F= 6.494$ ;  $P= 0.012$ ):  $49.3 \pm 24.1\%$ a,  $68.7 \pm 24\%$ b,  $80.6 \pm 27.7\%$ b,c and  $90.5 \pm 23.2\%$ c for respectively MLSS-10W, MLSS-GET, GET and 50% GET condition. The  $W'$ BAL model respectively over- and underestimated recovery time at the highest and lowest recovery work rate (i.e., MLSS-10W and 50% GET, respectively).  $W'$ ACT was negatively correlated with the absolute recovery work rate ( $r= -0.548$ ) and positively correlated to DCP ( $r= 0.458$ ).

**CONCLUSION:**

The applicability of the  $W'$ BAL model seems affected when recovery takes place at both high (overestimation) and low (underestimation) recovery WL, despite the integration of DCP in the calculation of the recovery time constant (t). A better understanding of the physiological mechanisms underpinning  $W'$  depletion and recovery is necessary to individualize the  $W'$ BAL relationship and increase both its predictive abilities and practical applicability.

**THE EFFECTS OF SELF-SELECTED VERSUS SET REST INTERVALS ON FATIGUE AFTER LOWER-BODY RESISTANCE EXERCISE**

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**INTRODUCTION:**

Those resistance training to enhance power output are typically provided with 3 to 5 minutes rest between sets. Allowing athletes to self-select (SS) their rest periods can help to maintain and augment their performance within a training bout. However, it is plausible that a higher external load (i.e. power) during training with SS rest periods can induce greater fatigue after exercise, though no study has sought to investigate this. Therefore, the aims of this study were twofold; 1) to determine if resistance trained males can SS their own rest periods, and 2) to evaluate the fatigue response after resistance exercise with SS rest periods.

**METHODS:**

Ten resistance trained males (age  $20.0 \pm 0.6$ y, mass  $86.6 \pm 12.5$ kg) attended the strength and conditioning laboratory for maximal squat strength test (1RM) before completing 5 x 5 squats (at 85% 1RM) with SS or set rest (SR) periods (3 minutes), in a randomised order. For the SS condition, participants started the set when they reached 4 ("adequately recovered") on the Edward's perceived readiness scale. During exercise heart rate (HR) and OMNI-RPE (at the end of each set) and peak velocity and power (each repetition) were recorded. Before and immediately after exercise, participants completed a maximal isometric squat and barbell squats at 20 and 80% 1RM.

**RESULTS:**

Though rest times were shorter in the SS than SR condition ( $P < 0.05$ ), HR and OMNI-RPE scores were comparable between conditions ( $P > 0.05$ ). Interestingly, external load markers (peak velocity and power) were higher in the SR than SS condition ( $P > 0.05$ ). Despite evidence of fatigue (i.e. reduction in all of the fatigue markers;  $P < 0.05$ ), there were no differences between groups ( $P > 0.05$ ).

**CONCLUSION:**

We report that a SS rest periods, using the perceived readiness scale, impairs external load markers during exercise. Importantly, despite a higher external load during exercise fatigue was not different between groups. Practically, these data suggest that resistance trained males should not SS their own rest periods when training for power output. Moreover, if practitioners are concerned about fatigue after exercise, SS or SR can be employed.

## REPETITIVE BRAKING OF A MOTORCYCLE REDUCES RATE FORCE DEVELOPMENT TO A GREATER EXTENT THAN MAXIMAL FORCE

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### INTRODUCTION:

Maneuvering a motorcycle in racing conditions or leisure time is sufficiently demanding that on many occasions forearm muscles arrive at a state of functional failure when riders cannot properly brake or operate the throttle. This study aimed to discriminate which one of the numerous dynamometric parameters used in the literature to characterize the Force-time (F-t) curve during voluntary contractions are more sensitive to fatigue in simulated motorcycle conditions.

### METHODS:

Thirty-three adults performed an intermittent fatiguing protocol (IFP) that simulated the braking and throttle handle actions using a hydraulic system equipped with a pressure sensor. Sixty pressure-time (P-t) curve parameters, including the rate of pressure development (RPD) and area under the curve were measured to characterize the time course of the braking maximal voluntary contraction (MVC). Two types of variables were used to analyze the P-t curve: 1) Times interval (30-50-100-500-1000 and 2000 ms), 2) Percentages of MVC (10-30-60-90%MVC).

### RESULTS:

In comparison to baseline condition, MVC decreased to 62%  $\pm$  17% of its initial value in the last round of the IFP ( $p < 0.001$ ). Ten minutes after the end of the IFP, MVC was still depressed by 19%  $\pm$  14% ( $p < 0.001$ ). It is noteworthy that no significant differences were observed at time windows shorter than 100 ms from the onset of the MVC for any of the raw and normalized variables. Overall significant ( $p \leq 0.05$ ) fatigue-related declines were observed only at time intervals longer than 100 ms and contraction intensities higher than 30%MVC. Strong and significant linear declines ( $p < 0.001$ ) were observed at 500ms and 1 s for normalized pressures, as well as for the ratio RPD60%MVC/MVC ( $p < 0.003$ ) throughout the IFP.

### CONCLUSION:

This study focused on 30 raw and 30 normalized kinetics-related parameters of the MVC to characterize the P-t curve of the braking action, with the objective to determine which ones of them are more relevant and discriminative of a fatigued state.

Usually, instrumental setup is as rigid as possible with the agonist muscle placed under a slight stretch. In the present study we decided to replicate the field condition in order to facilitate the applicability of the information to the technical staff, coaches and motorcycle riders. As a consequence of our approach longer time is needed to register initial increases of pressure inside the hydraulic braking system.

Our results suggest taking into account RPD at time intervals from 500 ms to 1 s, and contractions intensities between 30% and 60% of MVC, as more suitable criteria to study fatigue-related decrements in performance instead of the habitual maximal voluntary force. Pressure, RPD (slope) and Area (representative of the impulse), have a very similar time course of change with the occurrence of fatigue. However, we would suggest using RPD for its extensive use in related investigations, and Area for its conceptual and interpretative meaning.

## FUTSAL TRAINING WITH TOPICAL HYPOXIA INCREASES PERFORMANCE AND MUSCLE ACTIVATION

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### INTRODUCTION:

The aim of this study was to investigate the effect of leg blood flow restriction (BFR) applied during a 3-a-side futsal game on strength-related parameters. [1,2,4]

### METHODS:

Twelve male futsal players were randomly assigned into two groups ( $n = 6$  for each group) during 10 training sessions either with or without leg BFR. Prior to and post-training sessions, participants completed a series of tests to assess futsal special performance test (FSPT) and leg strength. [3] Pneumatic cuffs were initially inflated to 110% of leg systolic blood pressure and further increased by 10% after every two completed sessions.

### RESULTS:

In comparison with baseline, FSPT was significantly better in the BFR group ( $p < 0.05$ ). Peak torque of knee extension and flexion increased in both groups ( $p < 0.05$ ). A trend of increased neural activation of all heads of the quadriceps was observed in both groups, however, it was statistically significant only for rectus femoris in BFR ( $p = 0.02$ ).

### CONCLUSION:

These findings indicated that the addition of BFR to normal futsal training might induce greater neuromuscular benefits by increasing muscle activation.

## MILD-EXERCISE TRAINING ACCELERATES FEAR EXTINCTION THROUGH HIPPOCAMPAL-BDNF SIGNALING

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### INTRODUCTION:

We previously revealed that even mild exercise causes hippocampal BDNF (brain-derived neurotrophic factor) induction and neurogenesis [1][2]. This leads us to postulate that mild exercise could be as beneficial as medications on some psychological disorders. Currently, with increased life-threatening events occurring throughout the world, individuals may develop long-term symptoms that can lead to diagnoses of Post-Traumatic Stress Disorder (PTSD). Cognitive-behavioral psychotherapies, such as exposure therapy, and drug therapy are often applied as first-choice interventions; however, more efficient and natural methods are needed. Thus, there is advocacy for mild-exercise training, since the induction of hippocampal neurogenesis [3] and BDNF signaling in the hippocampal-prefrontal cortex tract reduces conditioned fear [4].

### METHODS:

Male Wistar rats (11 weeks old) were used. Exp. 1 examined whether 4 weeks of mild-intensity exercise (MI) and moderate-intensity exercise (MO) accelerates the extinction of hippocampus-dependent contextual fear memory (CFM) as well as amygdala-dependent auditory fear memory (AFM) using a conditioning chamber. Exp. 2 examined the effect of 4 weeks of MI and MO on hippocampal BDNF protein expression using Western Blotting. Exp. 3 examined whether chronic i.p. injection with ANA-12, a specific antagonist for brain TrkB (tropo-

myosin receptor kinase B; the main receptor of BDNF), suppresses the fear memory extinction induced by MI (the effect of which was shown in Exp. 1); subsequently, whether BDNF signaling was actually suppressed by the antagonist was assessed using protein expression with Western Blotting (Exp. 3).

**RESULTS:**

Both MI and MO accelerated CFM extinction, but not AFM extinction (Exp. 1). MI significantly increased hippocampal BDNF protein and TrkB protein (Exp. 2). I.P. Injection of ANA-12 suppressed the fear memory extinction induced by MI. The expression levels of hippocampal BDNF protein and TrkB protein were significantly higher in the MI + Saline group than in the Sedentary + Saline group and the MI + ANA-12 group (Exp. 3).

**CONCLUSION:**

These results reveal for the first time that mild exercise training for 4 weeks accelerates hippocampal-dependent CFM extinction by activating hippocampal BDNF signaling. Mild exercise training, a stress-free and easily done intervention, could be an efficient treatment for PTSD.

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## HEART RATE VARIABILITY OF RUSSIAN NATIONAL TEAM ATHLETES AT FUNCTIONAL TESTS.

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**INTRODUCTION:**

Heart rate variability is a golden standard method for modern sport sciences. Most studies and recommendations provide us data about HRV measurements and analysis for rest conditions, while there are only few studies about HRV at maximal and submaximal loads, especially in elite sports. The aim of our research was to study the peculiarities of HRV of highly trained athletes – members of Russia National Teams during stress tests.

**METHODS:**

36 elite athletes, members of Russian national team (various sports), age 24.89±3.98 y., 14 male and 21 female were included in the study. For each athlete interbeat in-tervals'd been measured with Polar H10 sensor during standard PWC-170 test. HRV parameters were calculated with Kubios Premium v. 3.1. We analyzed three segments of measurements (length 2 min) – preload, maximum load and recovery phase. For statistical calculation Knime Analytic Platform and Python 3 had been used, to confirm the differences between segments we used one-way ANOVA stat. test.

**RESULTS:**

HRV parameters were for preload phase/maximum load/recovery phase RMSSD (ms) 33.56±46.33/2.7±1.19/15.98±14.53, SDNN(ms) 54.14±48.55/15.51±7.07/64.03±32.35, SD1(ms) 23.81±32.9/1.92±0.84/11.36±10.3, SD2(ms) 71.96±59.19/21.75±10/89.17±44.8, SD2/SD1 3.78±1.21/12.43±5.75/11.98±7.77, DfFa1 1.22±0.25/0.8±0.32/1.31±0.29, DfFa2 1.03±0.21/1.6±0.2/1.32±0.29. SNS indexes are 2.65±1.74/24.7±6.99/6.22±3.11 and parasympathetic nervous system(PNS) indexes are -1.29±1.43/-4.19±0.31/-2.67±0.73 (p-value for each var. <0.001).

**CONCLUSION:**

Elite athletes at preload phase demonstrates significant prevalence of parasympathetic regulation. We founded that at maximum loads parasympathetic regulation is suppressed by sympathetic, which demonstrates a decreasing trend at the recovery phase. Autonomous regulation of elite athletes at the recovery phase is much more sympathetic than at preload phase. We continue our research to analyze and compare regulation patterns of elite and nonprofessional athletes.

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## INERTIAL SENSOR-BASED MOTION TRACKING IN FOOTBALL WITH MOVEMENT INTENSITY QUANTIFICATION

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**INTRODUCTION:**

In football matches, hamstring strain injuries (HSI) occur most frequently during the latter stages of each half [1]. Fatigue may induce changes in hamstring contractile strength and sprinting technique, which are potential causes for the observed increase in HSI risk. The aim of this study was to examine the effects of football specific fatigue on hamstring maximal voluntary torque (MVT), rate of torque development (RTD), sprint performance, and sprinting kinematics.

**METHODS:**

Six amateur football players executed a 90-min football match simulation [2]. Immediately before and after each 15-min segment of the simulation, 20m sprint time from standstill was recorded. Since hamstring muscle strain during sprinting is the resultant of combined changes in knee and hip angle, changes in these angles during sprinting were studied using 5 small inertial measurement units fixed to shanks, thighs and lower back. Sixty seconds after the 20m sprint, isometric knee flexion strength was tested. MVT, RTD (calculated as torque-time integral for intervals 0-50ms, 0-100ms, and 0-150ms after torque onset), and rectified surface EMG activity of the m. biceps femoris long head and medial hamstrings were assessed. Repeated measures ANOVA's with Greenhouse-Geiser corrections were used to determine time-dependent changes and effect sizes are reported as Partial Eta<sup>2</sup>. Repeated measures correlation coefficients (r) were



calculated to quantify common within subject associations between hamstring contractile strength, sprint performance, and sprinting kinematics.

**RESULTS:**

Sprint times increased over time ( $p = .086$ ,  $\text{Eta}^2 = .420$ ) from  $3.51 \pm 0.14$  s before the match simulation to  $3.79 \pm 0.37$  s after 90 min. MVT declined from  $113.5 \pm 10.6$  Nm to  $103.0 \pm 8.9$  Nm ( $p = .059$ ,  $\text{Eta}^2 = .411$ ) as did the corresponding EMG activity ( $p = .061$ ,  $\text{Eta}^2 = .395$ ). Measures of RTD remained unchanged ( $p = .275$ -.431,  $\text{Eta}^2 = .186$ -.274). The decreases in hamstring MVT were related to a greater peak knee extension just before touch down of the feet ( $p = .019$ ,  $r = .357$ ), which was accompanied by decreases in peak hip flexion ( $p = .004$ ,  $r = .431$ ), resulting in a constant combined knee and hip flexion/extension angle ( $p = .509$ ,  $r = -.104$ ) around the instance of potential maximal muscle strain in the step cycle.

**CONCLUSION:****CONCLUSIONS:**

These preliminary findings suggest that MVT and the capacity of the hamstrings to decelerate the lower leg in sprint running decrease during football-specific fatigue. It may be speculated that the associated smaller peak hip flexion angles protect the weakened muscles against hamstring strain injury.

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**ASSESSING MUSCLE FATIGUE WHEN RIDING A RACING MOTORCYCLE**

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*INEFC*

**INTRODUCTION:**

Motorcycle road races last from 30 to 45 minutes, representing about 20 to 25 laps consisting of 12 to 20 curves. This profile requires thereby 200 brakes and 400 leans per race at velocities generally greater than 200 km/h that should be managed with accurate synergistic muscle contractions from different part of the body, despite the development of muscle fatigue. The objectives of this case study were 1) to assess the muscle activity changes while riding on a road-race track, and 2) to describe whether or not muscle fatigue develops when riding a motorcycle during consecutive rounds of a training session on a circuit.

**METHODS:**

The EMG signals were recorded unilaterally from Biceps Brachii (BB), Triceps Brachii (TB), anterior and posterior part of the Deltoid (DA and DP respectively), Flexor Digitorum Superficialis (FS), Extensor Carpi Radialis (CR), Extensor Digitorum Communis (ED) and Pectoralis Major (PM) during three rounds of 30 min. EMG signals selected for analysis came from the beginning of the braking action to the way-out of the curves of interest.

A specific isometric maximal voluntary contraction (MVC) for each muscle was used for normalization purposes of the EMG signals recorded during the riding. During the track session, the rider performed three rounds of 30 min duration each with 30 minutes of rest between them. The Joint Analysis of EMG Spectrum and Amplitude (JASA method), proposed by Luttmann et al., (1996), was used to study the time and frequency domains of the EMG signal. The level of significance was set at 0.05.

**RESULTS:**

EMG signals were consistent and the muscle contractions corresponding to each sector of the track were easily detectable. Considering the laps and rounds as a whole and focusing on the forearm muscles, the ED was more systematically (84%) assigned to a state of fatigue than the FS (44%) and CR (39%). On the opposite, the TB and DP muscles showed a predominant state of force increase (72%). Whereas the BB denoted alternatively a state of fatigue or force increase depending on the side of the curve, when taking into account only the sharpest curves, it showed a predominant state of force increase.

**CONCLUSION:**

This study provides descriptive information about muscle behavior while riding a motorcycle on a race-track. The results suggest that the ED muscle was more demanded and fatigued than the FS and CR. Whereas PM and DA muscles were fatigued especially in the last round, TB and DP muscles showed a state of force increase. This state was particularly predominant in the BB muscle in the sharpest curves.

This study is a step forward towards knowing the fatigue behavior of muscles involved when riding a motorcycle in real race track conditions, and should help coaches to design specific strength training programs focused on the upper body musculature.

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**ABNORMALITIES IN GLUTAMATERGIC AND DOPAMINERGIC SYSTEMS LEAD TO THE IMPAIRED CORTICOSTRIATAL PLASTICITY AFTER EXERCISE-INDUCED FATIGUE**

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**INTRODUCTION:**

Exercise-induced fatigue (EF) is common in sports training and competitions, it affects athletes' motor skill execution and cognitive function. Corticostriatal synaptic plasticity is regulated by both the glutamatergic system and dopaminergic system, and is considered to be the cellular mechanism of movement control and sports skill learning. However, the effect of EF on corticostriatal synaptic plasticity are not well known. In our previous study, for the first time we reported that the long-term potentiation (LTP) and long-term depression (LTD) in corticostriatal pathway were both impaired, and the function of postsynaptic NMDA receptor was down-regulated in EF mice. The aim of the present study is to further explore the mechanisms underlying this impaired corticostriatal plasticity, and investigate the role of glutamatergic system and dopaminergic system in resulting this impaired corticostriatal plasticity after EF.

**METHODS:**

Adult male C57BL/6 mice were randomly divided into two groups: control mice (Control) and exercise-induced fatigue mice (EF). EF mice were forced to run on an electric treadmill until fatigue daily for seven consecutive days, while control mice did not perform the treadmill exercise. High performance liquid chromatography (HPLC) was used to examine the concentration of glutamate (Glu) and dopamine (DA) in the striatum. Western blot was used to detect the expressions of glutamate receptor 1 (GluR1), glutamate receptor 2 (GluR2), metabo-

tropic glutamate receptor 1 (mGluR1), dopamine 1 receptor (D1R), dopamine 2 receptor (D2R), and cannabinoid 1 receptor (CB1R) in striatal membrane proteins of EF mice and control mice.

#### RESULTS:

The results of HPLC showed that after EF, the concentration of Glu was increased ( $P < 0.05$ ), and the concentration of DA was decreased ( $P < 0.01$ ) in the striatum of EF mice. Compared with control mice, the expression of striatal GluR1 and GluR2 in EF mice were normal, but the expression of mGluR1 ( $P < 0.01$ ), D1R ( $P < 0.001$ ), D2R ( $P < 0.001$ ) were all decreased, the expression of CB1R was increased ( $P < 0.01$ ) in striatal membrane proteins of EF mice. Both glutamatergic and dopaminergic systems were abnormal after EF in mice.

#### CONCLUSION:

Taken together, in glutamatergic system, the concentration and release of Glu were increased, NMDA receptor function was down-regulated and the expression of mGluR1 was decreased in the striatum of EF mice; in dopaminergic system, the DA concentration was reduced and the expression of D1R and D2R in the striatum were decreased. The double abnormalities in glutamatergic and dopaminergic systems may be the neural mechanisms underlying that EF impairs corticostriatal plasticity. The increase of CB1R expression in the striatum may be a compensatory response to eliminate the excessively accumulated Glu and recover the corticostriatal LTD.

### INTER-LIMB ASYMMETRIES FOLLOWING A UNILATERAL COUNTERMOVEMENT VERTICAL JUMPING PROTOCOL

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#### INTRODUCTION:

Inter-limb asymmetries have been widely recognized as a contributing factor to suboptimal sport performance and a variety of lower limb injuries [1]. When these asymmetries are associated with differences in strength and function of the muscles surrounding the hip region they may influence the function of more distally located joints inducing compensation and eventually injury [2]. It is commonly accepted that unilateral overloading, such as countermovement vertical jumping that is performed by a wide variety of athletes during training and competition, can increase inter-limb neuromuscular differences, increasing the likelihood of injury. The purpose of the study was to examine the effect of a unilateral countermovement vertical jumping (UCMVJ) protocol on the functional ability of the lower extremities.

#### METHODS:

The functional ability of the lower extremity was assessed bilaterally in 10 healthy physical active subjects (5 males and 5 females) by means of (i) the isometric strength of the abductors, adductors, external rotators and internal rotators of the hip, (ii) the postural stability, based on the reaching distances and the center of pressure (CoP) parameters recorded during the Y-balance test and (iii) gait parameters, before and after a UCMVJ protocol. The isometric strength of the hip musculature was measured with a hand-held dynamometer and both the CoP- and gait-based parameters were measured with a plantar pressure distribution platform. The protocol included 5 sets of 20 maximum UCMVJ performed on the supportive leg, with a 30-s break between sets.

#### RESULTS:

Our findings revealed that the functional ability of the lower extremity was not affected by the UCMVJ protocol despite the resulted significant decline ( $p < 0.01$ ) in vertical jump performance (17.1%) and the associated twofold increase in perceived exertion ( $p < 0.001$ ). The isometric strength of the hip musculature was either slightly increased or remained unaffected. Postural stability remained also unaffected although the trained limb demonstrated a non-significant decrease in all CoP-based parameters tested. Similarly, the gait-based parameters, such as the heel to forefoot time and maximum foot pressure, following the UCMVJ protocol, were not significant affected in both extremities.

#### CONCLUSION:

The lack of inter-limb differences in muscle strength, postural stability and gait parameters suggested that the decline in vertical jumping performance induced by a 100 UCMVJ session does not affect lower extremity function and probably sports performance. Furthermore, potential injuries that occur at the distal joints of the lower extremity, as a result of similar loading conditions, cannot be justified by the dysfunction of the hip musculature.

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### THE INFLUENCE OF DIFFERENT TRAINING LOAD QUANTIFICATION METHODS ON THE FITNESS-FATIGUE MODEL.

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#### INTRODUCTION:

Today there are numerous ways of quantifying training load (TL), making it difficult for practitioners to choose the most appropriate method. It is suggested that the best TL method, is the method that is able to relate TL to performance. Relating training to performance is done by using the fitness fatigue model. The purpose of this study was thus to test different TL methods within the fitness-fatigue model and to investigate the influence of the quantification methods on the outcomes of the model.

#### METHODS:

A modelling longitudinal research design was used to compare performance, fitness and fatigue over an 11-week period. An 8 week training period was implemented where subjects completed 3 interval training sessions per week. Before every third training session of the week, the subjects also performed a 3 km time trial (TT) in order to monitor the weekly changes in performance. After the training period, there was a 3 week follow-up period where subjects stopped training and only performed the TT on Fridays so that the effect of dissipating fatigue and/or fitness could be monitored. Ten healthy physically active men ( $22.0 \pm 1.6$  yr.,  $177.5 \pm 4.5$  cm,  $73.0 \pm 9.3$  kg,  $VO_{2peak} = 55.2 \pm 7.2$  ml.min<sup>-1</sup>.kg<sup>-1</sup>) participated voluntarily for this study. Banister TRIMP (bTRIMP), Lucia TRIMP (luTRIMP), Edwards TRIMP (eTRIMP), Rating of perceived exertion (TLRPE) and the Training Stress Score (TSS) were calculated for all training sessions.

#### RESULTS:

Although the power output over different training sessions was identical, the resulting internal TL decreased over time. This drop is more pronounced in the first training phase (week 1 to week 4) than in the second training phase (Week 4 to week 8) ( $-15.4\% \pm 12.8$  vs.  $-0.039\% \pm 12.1$  respectively,  $p < 0.001$ , CI:  $[-22.7 - -7.4]$ ). In the first period, this drop was more pronounced in bTRIMP than in the other methods ( $p < 0.05$ ), except for TLRPE ( $p = 0.124$ ). The fitness fatigue model was able to relate TL to performance with only a small error ( $1.5 - 2.1$  %).

The mean values of the output parameters across all methods for 1, 2, k1 and k2 were 13.2 days  $\pm$  2.9, 9.3 days  $\pm$  2.1, 0.59 au.  $\pm$  0.16 and 0.67 au.  $\pm$  0.20 respectively. Small, but significant, differences were found between methods.

### CONCLUSION:

We conclude that, although the differences in model output are limited, TL methods cannot be used interchangeably since they evolve in a different way. Also, a combination of external and internal TL methods seems warranted.

## OP-AP05 Running, Sprint performance and Agility

### THE EFFECT OF INDIVIDUALIZED POWER-TRAINING BASED ON FORCE-VELOCITY PROFILING IN ELDERLY MEN

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#### INTRODUCTION:

A recent study showed that physical functioning, frailty and quality of life was related to individual differences in the F-V relationship of elderly adults (1). Hence, it has been proposed that an individual training program aiming to improve the least developed capacity can be more effective to improve performance and physical functioning compared to traditional power training. The aim of the present study was therefore to investigate the effectiveness of an individualized power training program based on force-velocity profiling on performance and physical functioning in elderly adults.

#### METHODS:

49 elderly men (67.7 $\pm$ 5.3yrs, 83.4 $\pm$ 10.5kg, mean $\pm$ SD) completed a 10-week training intervention with two sessions per week. Stratified upon their f-v profile (high force or high velocity) in Keiser leg-press, participants were randomized to either a balanced power training group [BP, n=25, one strength and one speed/power session], or two groups training towards their least developed capacity (heavy strength training [HST n=11,] or a speed and power training [ST, n=13] group). F-v profiles were assessed in Keiser leg-press and benchpress with incremental loads. In addition, sit-to-stand, balance, timed up and go, stair climbing test with (20kg) and without additional load and grip strength were assessed before and after the intervention. M.vastus lateralis thickness and architecture were measured by ultrasonography.

#### RESULTS:

There were no differences in any performance or physical functioning measurement between the BT group and the individualized groups combined (HST+ST), except for grip strength (BP: 3.5 $\pm$ 7.7% vs. HST+ST: 7.3 $\pm$ 4.5%, p=0.03) and "stair climbing with additional load" (BP: -6.3 $\pm$ 3.8% vs. HST+ST: -2.4 $\pm$ 7.3%, p=0.03). The HST increased benchpress maximum force (F0) (10.0 $\pm$ 5.2% vs. 3.6 $\pm$ 9.5%, p=0.03) and one repetition maximum (1RM) (11.3 $\pm$ 7.1% vs. 3.1 $\pm$ 5.9%, p=0.01) more than the velocity group. Furthermore, both the HST and BP group increased muscle thickness more than the velocity group (8.2 $\pm$ 8.3% and 6.8 $\pm$ 7.5% vs. 1.5 $\pm$ 5.3%, respectively, p>0.035). There were no group differences in changes of leg-press and benchpress maximal power (Pmax), but only the BP group increased leg-press (4.8 $\pm$ 6.7%, p<0.01) and benchpress (7.7 $\pm$ 9.3%, p>0.01) Pmax from baseline. The BP group decreased the "stair climbing with additional load"-time more than the HST group (-6.3 $\pm$ 3.8% vs. -0.5 $\pm$ 6.9%, p=0.01), whereas the HST group increased grip strength more than the BP group (8.1 $\pm$ 3.6% vs. 3.5 $\pm$ 7.7%, p=0.03).

#### CONCLUSION:

Individualizing power training programs based on their least developed capacity from FV-profiles in leg-press were ineffective for improving performance and physical functioning measures. Caution should be taken when recommending this approach for elderly males. Overall, heavy strength training and a balanced approach seemed most beneficial for elderly adults.

Alcazar et al. *Experimental gerontology*, 2018

### SPRINT MECHANICAL DETERMINANTS OF CHANGE OF DIRECTION PERFORMANCE IN BASKETBALL

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#### INTRODUCTION:

Horizontal force application is predominant during sprint acceleration (1) and change of direction (COD) (2) tasks. However, the limited access to force platforms makes difficult to examine the association of horizontal parameters during acceleration with COD performance in common sport scenarios. Therefore, alternative methods need to be used. This study aimed to evaluate gender-specific associations of mechanical variables derived from the sprint force-velocity (FV) profile (i.e. theoretical maximal force [F0], velocity [V0], maximal power output [Pmax], the peak of the ratio of effective horizontal component [RFpeak] and the index of force application technique [DRF]) (3) with COD performance in basketball players.

#### METHODS:

A case series of 3 athletes with nearly same 20 m sprint time but different mechanical properties and COD performance. The sprint force-velocity (FV) profile (i.e. theoretical maximal force [F0], velocity [V0], the maximal power output [Pmax], the ratio of effective horizontal component [RFpeak] and the index of force application technique [DRF]) (3) and the 505 test (4) were assessed.

#### RESULTS:

FV profile parameters were significantly higher in men than women. F0, RFpeak and Pmax were strongly associated with performance in 505 test (women r range = -0.72 to -0.82; men: r range = -0.67 to -0.75) and V-cut test (women r range = -0.68 to -0.76; men r range = -0.45 to -0.50) as well as lower COD deficit (women r range = 0.58 (p<0.01) to 0.75; men r range = 0.49 to 0.54) (all p<0.001). Linear regression analysis estimated that one N/kg increase in the F0 was associated with a significant reduction in COD time and COD deficit in both genders.

#### CONCLUSION:

The present results provide practitioners with rationale to assess the sprint FV profile when the aim is to enhance sprint acceleration and COD performance. Therefore, this simple field method would be recommendable to evaluate horizontal force component in field practice to individualize training program based on athletes' sprint mechanical properties.

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## SEASONAL VARIATION OF THE ACCELERATION-DECELERATION (AD) RATIO BY POSITION IN BASKETBALL

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### INTRODUCTION:

Basketball demands athletes to perform multiple accelerations and decelerations, experience rapid changes of direction, and perform numerous jumps with little recovery in between. These movements place biomechanical loads on the athlete's body, which can build up and vary over time. Recent research has shown promise that a ratio using accelerations and decelerations may reveal changes in an athlete's performance, as well as position-specific demands and gender profiles <sup>1</sup>. There is, however, limited research quantifying acceleration-deceleration (AD) ratios longitudinally while incorporating game data. Thus, the aim of this study was to investigate an AD ratio as a potential metric for changes in athletes' performance, as well as explore position-specific profiles over the course of a single basketball season.

### METHODS:

Accelerations and decelerations of seven collegiate (NCAA D-I) basketball players were collected for 30 games and 89 practices during the 2019-2020 season. These players played more than 20 games (>65% of the season) and averaged more than 10 min a game (>25% of game duration). Players were grouped by position: guard (n=2), wing (n=3), and post (n=2). Data were gathered using Catapult Optimeye S5 devices (Melbourne, Australia). The AD ratio was calculated using the total accelerations over the total decelerations per player. The AD ratio is presented by mean, standard deviation, and coefficient of variance (CV), and differences were statistically evaluated (ANOVA).

### RESULTS:

The AD ratio was significantly different for player position ( $p < 0.001$ ). Guards and wings ( $0.64 \pm 0.162$  and  $0.57 \pm 0.187$ ) had significantly lower AD ratios than posts ( $0.84 \pm 0.107$ ,  $p < 0.05$ ). The guards and posts had the most stable profiles with CV's of  $26.7\% \pm 18.6$  and  $26.5\% \pm 14.2$ , whereas the wing profile had the highest CV ( $40.2\% \pm 32.8$ ).

### CONCLUSION:

All players generated more decelerations than accelerations (i.e., AD ratios were below 1), but the AD ratios were significantly different among the players' positions. Perimeter players (guards and wings) were found to be not statistically different, however, they had statistically lower AD ratios than post players. These results aligned with previous research where perimeter players had lower AD ratios than post players <sup>2</sup>. The current results suggested that perimeter players experienced different biomechanical loads than post players in relation to the amounts of accelerations and decelerations. Furthermore, the AD ratio also produced stable profiles with CV's below 40%, indicating small variations for individual players across the season. The AD profiles showed sensitivity for detecting changes in positional workload distributions and individual performances.

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## PACING STRATEGIES OF 800M COMPETITIVE ATHLETES IN INDOOR RACES

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### INTRODUCTION:

In 800 m event, elite athletes tend to adopt a positive pacing strategy (speed reduction throughout the race) during meeting races but a positive or negative (speed increase throughout the race) strategy in championship races [1]. Athletes pacing strategies have been studied in outdoor races by recording the split times every 200m. [2]. The aim of this study was to analyze the pacing profile in competitive athletes during indoor 800 m event.

### METHODS:

Seventy-one men ( $22.5 \pm 10.5$  years old;  $129.7 \pm 9.5$  s in 800m) and fifty-six women ( $23.7 \pm 12.2$ ;  $160.4 \pm 14.3$  s in 800m) performed a 800 m official indoor race (December 2018). The event was not a championship event (no prizes according to athletes finishing positions), so athletes would be expected to adopt a pacing strategy aim for the best possible time. 800m races were video-recorded at 30Hz and intermediate times each lap (200m) were obtained. The following variables were calculated: split times of each lap (SPLIT), the difference between the first split time and the remaining three split times (DIF) and difference between the mean split time and four split times (MEAN). A repeated-measures ANOVA was used to detect changes between laps (1st to 4th) and Bonferroni post-hoc procedures were employed in case of significant main effect. Pearson correlation coefficients were used to relate race parameters to the race result. Significance was set at  $P < 0.05$ .

### RESULTS:

SPLIT increased ( $p < 0.001$ ) with each lap, except from third to fourth lap. SPLIT3 showed the highest correlations (nearly perfect) with the race time (men  $r = 0.98$ ; women  $r = 0.97$ ;  $p < 0.001$ ), followed by the SPLIT2 (men  $r = 0.95$ ; women  $r = 0.95$ ;  $p < 0.001$ ). DIF3 showed the greatest ( $p < 0.001$ ) correlation (very large) with the race time, both men ( $r = 0.70$ ) and women ( $r = 0.77$ ). MEAN3 obtained the highest positive relationship with official time (men  $r = 0.70$ ; women  $r = 0.50$ ;  $p < 0.001$ ), whereas MEAN1 showed the highest negative relationship (men  $r = -0.59$ ; women  $r = -0.76$ ;  $p < 0.001$ ).

### CONCLUSION:

Competitive athletes adopt a positive pacing strategy in 800m indoor races. The greatest positive correlations with race result were observed in the third lap (SPLIT3, DIF3 and MEAN3). However, the negative relationship of MEAN1 with the race result suggest that the fastest athletes performed a slower SPLIT1. This could assist them to perform a shorter SPLIT3 and, consequently, minor differences with SPLIT 1 and mean split. Accordingly, athletes and coaches should keep in mind that the fastest 800m runners seem to adopt a more conservative positive pacing strategy to improve the finishing time.

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**VISUAL SPEED DOES NOT AFFECT TIME TO EXHAUSTION BUT TIME PERCEPTION DURING TREADMILL RUNNING IN A VIRTUAL ENVIRONMENT**

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**Introduction**

(Subliminal) visual cues may affect endurance performance and time perception. Aim of this study was to test the effect of the speed of virtual visual cues on time to exhaustion (TTE), perceived fatigability and time perception while treadmill running in a virtual environment.

**Methods**

After an incremental exercise test to assess velocity at peak oxygen uptake ( $vVO_{2peak}$ ) and familiarization with the experimental setup, ten healthy males performed two different running sessions (randomized, single blinded cross-over design): running at 90% of  $vVO_{2peak}$  until exhaustion at either treadmill-matched visual speed (MATCHED, 100% of treadmill) or at increased visual speed (INCREASED, 170% of treadmill speed). During the test protocol perceptual responses (attentional focus, feeling, arousal, dominance, perceived effort, strain, and action crisis conflict) were monitored at several time points to assess the dynamics of perceived fatigability. Perceptual responses were compared at three time points: one minute after the start (START), at half time (ISO50%) and at exercise cessation (ISO100%). To assess virtual flow effects on time perception a retrospective time estimation paradigm was used, i. e. participants were asked immediately after the run to estimate the elapsed time duration (EETD) in minutes and seconds. The mismatch between EETD and chronological TTE was calculated for each condition by the EETD/TTE ratio.

**Results**

No significant effects of visual speed condition were found for TTE and perceived fatigability at START, ISO50%, and ISO100%. After both TTE sessions, EETD was judged significantly shorter than chronological TTE ( $T_{MATCHED(1,9)} = 4.619$ ,  $p = 0.002$ ;  $T_{INCREASED(1,9)} = 3.417$ ,  $p = 0.016$ ). Further, there was a high correlation ( $r = .928$ ,  $p < 0.001$ ) and a significant smaller mismatch, i. e. lower EETD/TTE ratio in the INCREASED condition ( $T(1,9) = -3.017$ ,  $p = 0.015$ ).

**Discussion**

Visual speed of a simple virtual environment does not affect TTE and perceived fatigability, but the mismatch between chronological and estimated time duration during exhaustive treadmill running. Environmental cues seem to affect time perception in experienced runners during a time to exhaustion protocol.

**THE POWER-RESISTANCE CURVE IN SPRINTING**

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**INTRODUCTION:**

Performance increases in high level track and field sprinting requires an optimization of the training tools, methods and loads. A common used sprint training method is sprints against resistance, f.e. sledge sprints, parachute sprints or sprints against elastic ropes. These tools are used to enhance the rate of force development and the power production during the sprinting strides (Gil et al. 2018). One major problem of these training methods is the determination of an optimal individual training load respectively the amount of resistance produced by these tools. Martin et al (1991) already determined the "muscle power threshold" as the point of culmination in the power resistance curve and defined this point as the power resistance of a muscle loop which is achieved by a defined resistance.

The aim of this study was the determination of a "power-resistance threshold" in sprinting.

**METHODS:**

16 elite youth track and field athletes who performed resistance sprinting exercises participated at this study. The resistance was applied by a 1080Motion system and was increased in +3kg male /+2kg female steps until the power value did not increase more than 100W. Then the resistance was increased in +1kg steps until the power at the last sprint (distance 30m) was lower than the power at the sprint before.

**RESULTS:**

For each of the participating athletes an individual power-resistance threshold could be determined. The mean power at this threshold was 1835W +/-17 for the male and 1030W +/- for the female sprinters. The maximum velocities at the threshold were 6,6m/s +/- 0,51 for male and 4,7m/s +/- 0,47 for female participants. The maximum speed obtained in unloaded conditions was reduced of 42% in male and 25% in female athletes. The applied resistance from the 1080Motion system at the threshold was 16,9kg +/-2,2 for male and 15,63kg +/-1,9 for female athletes.

**CONCLUSION:**

A power-resistance threshold could be determined for all athletes. The reduction of velocity at the threshold was significant different between the male and the female athletes. There are significant differences in relative velocity reduction between male and female athletes. However the load at the threshold between them is not significantly different. This result leads to the proposal of a gender specific load determination during resisted sprint exercises. Female athletes need higher body weight related weights than male athletes. Furthermore, the individual differences between all athletes implies that the load parameters for resisted sprints must be individualized. Regarding the special training effects of these high resistance values it can be assumed, that the relative high resistances lead to an increased leaning forward position of the trunk and therefore to an optimized force transmission in horizontal direction.

**Conclusion**

Identifying the power-resistance curves of athletes allows the optimization of load determinations in resisted sprint training sessions and therefore to a higher quality of training.

**CHANGES IN FORCE-VELOCITY PROFILE AFTER A SHORT VS LONG MOUNTAIN ULTRAMARATHON RACE**

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**INTRODUCTION:**

The Force-Velocity profile (FVP) is used to describe dynamic force production capacities which is of great importance for high level athletes (1). Fatigue is often quantified using the changes in isometric force but the effects of extreme fatigue on FVP remain unknown. The aim of our study was to examine the effects of completing a mountain ultramarathon of long vs short distance on FVP, i.e. theoretical maximal force (F0), theoretical maximal velocity (V0), slope of the force-velocity relationship (Sfv) and maximal mechanical power output (Pmax) (2).

#### METHODS:

Forty-six athletes (30 males, 16 females), participating in different races of the Ultra-Trail du Mont-Blanc, ranging from 40 km and  $\pm 2,300$  m of elevation to 170 km and  $\pm 10,000$  m, were recruited. All athletes visited our laboratory 5-8 weeks before the event, for a familiarisation session. 24-48 h before the race (PRE), participants performed two sprints of 7 s on a Monark cycle ergometer with a resistance corresponding to 0.5 N.kg<sup>-1</sup> and 0.7 N.kg<sup>-1</sup> of body mass. Within 2 h of finishing the race (POST), participants performed again two sprints of 7 s on a Monark cycle ergometer with a reduced resistance ( $\sim$  -30-35%) corresponding to 0.3 N.kg<sup>-1</sup> and 0.5 N.kg<sup>-1</sup> of body mass. F0, V0, Sfv and Pmax, i.e. the product of F0 and V0 divided by 4, were determined for both PRE and POST. Athletes were split in two groups according to race distance: LONG (> 100 km) and SHORT (< 100 km). The effect of race distance on change in FVP parameters was evaluated using a 2-way (time x distance) ANOVA.

#### RESULTS:

While Sfv and V0 decreased significantly ( $p=0.035$  and  $p=0.039$ , respectively) between PRE and POST, independently of the distance, the time x distance interaction was significant for the other two parameters. Pmax was significantly reduced in POST compared to PRE ( $p<0.001$ ) for both SHORT and LONG distances, by  $7\pm 10\%$  and  $17\pm 12\%$ , respectively. F0 was significantly lower in POST compared to PRE ( $p<0.001$ ), but the post-hoc test showed the decrease was significant only for the LONG distance ( $-15\pm 16\%$ ,  $p<0.001$ ).

#### CONCLUSION:

As expected, running a mountain ultramarathon has a negative impact on FVP as all parameters were significantly lower in POST compared to PRE. The study adds to literature by showing that the race distance was an interacting factor for F0 and Pmax only and suggesting that the force capacities were more sensitive to extreme fatigue than the velocity abilities.

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## OP-AP06 Swimming, Cycling, Triathlon

### LONGITUDINAL AGE-RELATED CHANGES IN CYCLING PEAK POWER AND SIMULATED 16.1KM TIME TRIAL PERFORMANCE

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#### INTRODUCTION:

We had previously reported the cross-sectional derived decline in peak power (Balmer et al 2005) and time trial performance (Balmer et al 2008) with age however there is very little information on the longitudinal decline in these variables with age.

#### METHODS:

15 male cyclists completed two maximal ramped Kingcycle ergometer tests and two indoor 16.1-km time trials (16.1km TT) separated by  $\sim 10$  years. An SRM power meter was used to measure mean power during the 16.1-km TT, and maximal ramped minute power (RMPmax) recorded as the highest average power during any 60s. Maximal heart rate (HRmax) was recorded as the highest value during the RMPmax test. The exact same test protocol and testing equipment was used to retest these participants.

#### RESULTS:

The average time between tests was  $9.7\pm 1.0$  years, during this time RMPmax had declined by 16.7% (95%CI: 56.2-79.9 W), HRmax declined by 5.7% (95%CI: 8.0-13.6 beats/min), 16.1km TT power declined by 15.2% (95%CI: 14.2-68.8 W) and 16.1km TT HR declined by 7.3% (95%CI: 7.4-17.9 beats/min).

#### CONCLUSION:

The decline in both maximal and 16.1-km TT performance measured longitudinally was more than double that which had previously been reported from x-sectional data. Therefore, researchers should be aware that x-sectional data may not represent the real life reductions in cycling performance with age.

### EFFECTIVENESS OF SPECIFIC HIGH INTENSITY WARM-UPS ON SIMULATED MIXED TEAMS RELAY TRIATHLON PERFORMANCE

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#### INTRODUCTION:

A sports-specific warm-up (WU) is important to prepare for the exact demands of competition. The intensity and modality of the WU may be important to maximise possible anaerobic and neurological benefits. Due to the increased intensity of the mixed teams relay (MTR), this study aimed to investigate the effect of three different high intensity (HI) WUs on MTR performance.

#### METHODS:

Six elite triathletes (3M; 3F;  $20.3\pm 1.9$ yr) performed one of three 20min WUs prior to a simulated MTR in a counterbalanced crossover design. WU1 (CON) consisted of 10min moderate intensity (MI;  $>65\%$ HRmax) running and 10min MI swimming. WU2 consisted of a 10min intermittent HI swim set building to race pace and HI intermittent cycling with 5x 10s 200% peak aerobic power (PP) sprints interspersed with recovery at 55% PP. WU3 consisted of 5min MI running, 10min intermittent sprint and skipping drills and, 5min dryland swim circuit. Each MTR simulation included a 300m indoor swim, 10.5min variable ergometer cycle and 1.8km outdoor run. One-way repeated measures ANOVA determined statistical differences ( $P = 0.05$ ) between WUs and Cohens d. (ES) assessed the magnitudes of effect.

#### RESULTS:

Run time was significantly improved ( $-14.13 \pm 7.7s$   $p=0.046$ ; ES 0.25 &  $-14.17 \pm 4.0s$   $p=0.01$ ; ES 0.27) following WU2 compared to CON and WU3. Overall simulated MTR time significantly improved ( $-14.48 \pm 6.9s$   $p=0.035$ ; ES 0.06 &  $-17.03 \pm 6.8s$   $p=0.016$ ; ES 0.19) following WU2 compared to CON and WU3. Additionally, WU2 produced significantly lower pre-run blood lactate concentrations ( $-4.0\text{mmol.L} \pm 0.8$ ,  $p=0.01$ , ES=1.67 &  $-3.4\text{mmol.L} \pm 0.8$ ,  $p=0.01$ , ES=1.42) compared to WU1 and WU3.

**CONCLUSION:**

WU2 appears to have significantly improved both running and overall MTR performance compared to CON and WU3. WU2 consisted of progressive anaerobic work compared to the aerobic nature of CON and the plyometric nature of WU3. WU2 may have upregulated specific pathways responsible for buffering that may have improved 'lactate tolerance' during the cycle. This may in turn have reduced the known decrement of a HI cycle effort prior to running, evidenced by the improved running performance following WU2. Having a specific HI cycle WU may have also biomechanically better prepared the triathletes and reduced the initial O<sub>2</sub> deficit within an MTR.

An individualised high intensity swim and cycle warm up is most effective for preparing athletes for the demands of the MTR. These results provide coaches and triathletes with information to make informed decisions regarding MTR pre-race WUs. Further research firstly, is required to determine what may be the most appropriate WU for athletes who start with a sprint into the swim rather than a dive start.

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**PREDICTING SPRINT TRIATHLON PERFORMANCE IN ELITE ATHLETES BASED ON THE LSCT; IMPLICATION FOR MONITORING AND OPTIMIZING TRAINING.**

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**INTRODUCTION:**

The monitoring of elite athletes on a regular basis is important as it facilitates and maintain a healthy balance between training and recovery as well as ensuring peak performance at the right time. The Lamberts Submaximal Cycle Test (LSCT) has shown to be able to predict, (1) fine tune training prescription (2) and indicate fatigue levels (3) in trained to elite cyclists. Although the LSCT gained popularity in the practical field of triathlon to monitor and optimize training in triathletes, no study does date has determined the relationship between the LSCT and triathlon performance. Therefore the aim of this study was to determine how well overall and leg specific (swimming, cycling and running) triathlon performance can be predicted from the LSCT in elite triathletes.

**METHODS:**

Six triathletes on the Dutch National Triathlon team who participated in the Dutch National Championships participated in the study. After familiarizing the athletes to the LSCT in the weeks leading up to the national championship, all triathletes performed the LSCT 2 days before Dutch National Championships. The data collected within the LSCT and specifically power generated at 80 and 90% of heart rate maximum were analysed and correlated to their overall and split sprint triathlon times.

**RESULTS:**

The results of the triathletes included 3 national titles (under 23 and elite), 2 fifth places and one twelfth place. Very good relationships were found between overall triathlon performance and power output (PO) during the LSCT ( $r = -0.96$ ,  $p < 0.01$ ). In addition, strong relationships were found between mean PO and cycling time ( $r = -0.97$ ,  $P < 0.001$ ) as well as running time ( $r = -0.93$ ,  $P < 0.01$ ). A slightly weaker, but nevertheless significant relationship was found between mean PO (LSCT) and swimming time ( $r = -0.89$ ,  $P < 0.05$ ).

**CONCLUSION:**

Good to very good relationships were found between mean PO during the LSCT and overall as well as split sprint triathlon times. These findings suggest that the LSCT, which is a cycling-based test, can be used to predict overall and leg specific triathlon performance. In addition, the good relationships also indicate the high potential that the LSCT can likely be used a valuable monitoring tool in triathlon. However future research needs to confirm this hypothesis, as well establish the accuracy of the LSCT in a more heterogenous group of triathletes.

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**NO EFFECT OF A THREE-WEEK POST-SEASON TRANSITION PERIOD ON MARKERS OF RED-S IN HIGHLY-TRAINED MALE CYCLISTS**

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**INTRODUCTION:**

Relative energy deficiency in sports (RED-S) is a syndrome that can impair athlete's health and performance. Highly-trained cyclists are especially vulnerable to RED-S within the competitive season [1]. The following post-season period includes a transition phase with reduced training load to facilitate physical and mental recovery. Interestingly, only a few studies have examined RED-S during the post-season recovery period in this group of athletes [1]. The aim of this study was therefore to examine how three weeks of reduced training load during the transition period affects markers of RED-S in highly-trained male cyclists.

**METHODS:**

Nine highly-trained [2] (VO<sub>2</sub>-peak:  $71.8 \pm 5.3$  mL/kg/min) male cyclists (age:  $22.3 \pm 3.7$  years, body mass:  $71.8 \pm 6.2$  kg, body fat:  $11.2 \pm 4.2\%$ ), competing at a national (n=6) and continental level (n=3), participated in this study. During a three-week individualized intervention period, all cyclists were instructed to reduce their training load by 70%. Training load was calculated individually by iTRIMP and the last four weeks of the competitive season were used as reference value. The intervention period commenced with pre-testing 72-96 hours after the cyclists last competitive race of the season. Testing included assessment of resting metabolic rate (RMR) via indirect calorimetry, body composition via Dual Energy X-ray Absorptiometry and fasting blood samples to measure biochemical markers of RED-S. Post-testing was completed at the same time of day ( $\pm 2h$ ), 21 days after pre-testing. All data were log-transformed and presented as custom effect in percent (mean  $\pm 90\%$ CI), with the true chances of change being Negative/Trivial/Positive.

**RESULTS:**

The cyclists reduced their weekly training load by  $69.7 \pm 3.4\%$  (100/0/0) during the intervention period. Body mass had a 93% likely trivial change  $0.3 \pm 0.7\%$  (1/93/7). Fat free mass and body fat percentage had a likely negative change  $-2.4 \pm 2.4\%$  (85/14/2) and  $4.8 \pm 5.7\%$

(88/8/4), respectively. There was an unclear effect in RMR ratio  $3.4 \pm 6.6\%$  (12/13/75) and relative RMR  $4.1 \pm 7.0\%$  (10/11/79), respectively. Blood markers, such as triiodothyronine (T3)  $0.6 \pm 5.0\%$  (28/27/45) and total testosterone  $8.2 \pm 11.6\%$  (8/5/87), had an unclear effect, while cortisol had a very likely positive change  $-19.9 \pm 16.1\%$  (3/1/96).

#### CONCLUSION:

A short period of reduced training load did not affect markers of RED-S. Hence, a three-week intervention period immediately after the competitive season may be insufficient to observe a change in these markers. Furthermore, all biochemical markers were within normal range at pre-testing and substantial changes were thus not expected. In conclusion, a three-week period of reduced training load immediately after the competitive season did not affect RED-S related markers in this small group of highly-trained male cyclists.

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### CORRELATIONS BETWEEN KINEMATIC PARAMETERS AND PERFORMANCE TIMES IN INDIVIDUAL AND RELAY SWIMMING STARTS

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#### INTRODUCTION:

Several studies have identified the key parameters which affect start performance in individual start (Fischer & Kibele, 2016; Tor, Pease, & Ball, 2015). However, there is no available data about the key features when performing relay start. Therefore, this study aimed to examine the correlation between the kinematic variables and the 5m time both in individual and relay starts.

#### METHODS:

Eleven elite-level swimmers performed 2x25m maximum efforts (one with individual and one with relay start) and 2D-DLT algorithms was used to calculate kinematic parameters during the block and aerial phases. Pearson's correlation coefficient was applied to interpret the relationships between start variables and 5m time being 0.1, 0.3, 0.5, 0.7 and 0.9, the threshold values that represented small, moderate, large, very large, and nearly perfect correlations (Hopkins, Marshall, Batterham, & Hanin, 2009).

#### RESULTS:

In individual start, block time, take-off horizontal velocity, take-off velocity and entry angle were very largely related to 5m time ( $r = -0.77$  to  $0.83$ ). Dissimilarly, in relay start, the very large correlation was found in take-off height ( $r = -0.86$ ) and entry distance ( $r = -0.90$ ) with 5m time. Also, changeover time ( $r = 0.69$ ) was largely related to 5m time.

#### CONCLUSION:

The current study identified different parameters in the correlations of individual or relay start, respectively, with the times to 5m. The results in individual start were in line with previous studies (Fischer & Kibele, 2016), demonstrating that block time, take-off horizontal velocity and entry angle were very largely related to 5m time. Whereas, changeover times, take-off height and entry distance were more important to 5m time in relay starts. Obviously, the ability to coordinate timing between the incoming swimmers and the swimmer on block highlights the importance of changeover time (Saavedra et al., 2014) compared to the greater importance of other kinematic parameters in individual start.

### SIX-WEEKS OF POLARIZED VERSUS PYRAMIDAL ENDURANCE TRAINING LED TO RELEVANTLY SUPERIOR IMPROVEMENTS ENDURANCE PERFORMANCE IN TRAINED TRIATHLETES: A RANDOMIZED CONTROLLED INTERVENTION STUDY.

RÖHRKEN, G., HELD, S., DONATH, L.

SPORTHOCHSCHULE KÖLN

#### INTRODUCTION:

Previous research indicated that macrocycles of polarized training can superiorly increase endurance performance compared to traditional pyramidal training. However, conclusive evidence in general and triathletes in particular is still lacking. Thus, the present randomized controlled trial examined the effects of a 6 weeks intervention applying a polarized intensity distribution on lactate threshold and maximal parameters during running and cycling.

#### METHODS:

Fifteen homogenous and moderately trained triathletes have been either assigned to an intervention (INT,  $n=7$ , 2 female/5 male, Age:  $29.1 \pm 7.6$ , Fitness Index: 4.91) or control group (CON,  $n = 8$ , 2 female/6 male, Age:  $30.3 \pm 6.1$ , Fitness Index: 4.94). The minimization method (Strata: gender, age, fitness level, training volume per week) has been applied for group allocation. INT used a polarized training intensity distribution (TID) with either low intensity (LIT) or high intensity interval training (HIT). Average training hours and anthropometric data showed no differences between CON and INT during the study period. To further quantify the level of polarization we used the polarization index, as first described in the study by Treff and colleagues, thereby applying an index  $> 2$  in INT ( $2.1 \pm 0.4$ ) and  $< 1$  in CON ( $0.9 \pm 0.3$ ) respectively. A pyramidal TID with either medium intensity (MIT) or LIT was applied to CON. Average training volume and anthropometric data showed no differences between CON and INT during the study period. Incremental cycling tests (+ 20-30W / 3min.) and running (+ 1.5km/h / 3min.) were performed before and after the intervention period until objective exhaustion level to assess submaximal (lactate threshold one (LT1), two (LT2) and maximal performance (Peak) indices.

#### RESULTS:

All participants have notably improved their performance in submaximal and maximal running (LT2:  $+ 2.75 \pm 4.82\%$ ,  $p = 0.03$ , Peak  $+ 5.37 \pm 6.15\%$ ,  $p < 0.01$ ). Moderate to large effect sizes of cycling and running performance change only displayed in INT (Run LT2 Cohen's  $d = -1.06$ , Run Peak Cohen's  $d = -2.03$ ). However, there were no practically relevant interaction effects in all performance outcomes between both groups. Correlations in all participants between time in LIT and performance changes at Cycling LT1 have been found.

#### CONCLUSION:

A polarized TID seems to induce higher adaption stimuli and might be superior in performance enhancement compared to a pyramidal TID. However, both programs can lead to notable and relevant performance improvements in triathletes. Although the sample size of this study underpins the pilot character, future studies should investigate whether stronger polarization regimen can lead to a different picture.



**PHYSIOLOGY AND BIOMECHANICS TO DETERMINE THE EFFECT OF WETSUIT SPEEDO THINSWIM® WHEN SWIMMING IN A COLD-WATER FLUME**

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**INTRODUCTION:**

To avoid hypothermia, the Fédération Internationale de Natation (FINA) allows the use of wetsuit in swimming events when the water temperature is between 16 to 20°C. However, improvements in performance produced by the use of wetsuit 1,2 in different distances highlights the importance in selecting the wetsuit according to thickness and fabric. The purpose of the present study was to assess the biophysical comparison between the wetsuit Speedo Thinswim® (2 mm of thickness in upper limbs, trunk and lower limbs, Nottingham, United Kingdom) and a training swimsuit when swimming in at 18°C water temperature.

**METHODS:**

Four male swimmers (age: 22.2±4.1 years; height: 180±0.04 cm; body mass: 79.4±10.3 kg; arm span: 191±11 cm; 400m freestyle personal best time: 78±6% of the World Record) performed two front crawl trials at 18°C (with wetsuit and swimsuit) in the swimming flume (randomized order; 24 h rest in-between), with swimmers 400m front crawl best time (298±54 s) and respective mean swimming speed ( $v$ , 1.44±0.33 m·s<sup>-1</sup>) being used for define the swimming flume trials. Peak oxygen uptake (VO<sub>2</sub>peak) and minute ventilation (VE) were assessed breath-by-breath using a telemetric portable gas analyzer and snorkel (K4b2 + AquaTrainer®; Cosmed, Rome, Italy), with maximal heart rate (HRmax; Polar Electro Oy, Kempele, Finland), peak blood lactate concentrations ([La-]; Lactate Pro analyzer, Arkray, Inc., Kyoto, Japan) and rate of perceived exertion (RPE) being obtained. VO<sub>2</sub> data were modelled using the mono-exponential model with VO<sub>2</sub>FITTING 3. Thus, energy cost (C), metabolic power (E) and total energy expenditure (Etot) were obtained. Stroke rate (SR), stroke length (SL), stroke index (SI) and propelling efficiency ( $\eta_p$ ) were calculated.

**RESULTS:**

No differences were found on VO<sub>2</sub>peak (wetsuit Speedo Thinswim®: 53.3±11.4 vs swimsuit: 51.8±3.0 mL·kg<sup>-1</sup>·min<sup>-1</sup>,  $p=0.80$ , Cohen's  $d$ : 0.14), VE (104±32 vs 107±23 l·min<sup>-1</sup>,  $p=0.67$ ,  $d$ : -0.23), C (0.8±0.13 vs 0.85±0.2 kJ·m<sup>-1</sup>,  $p=0.33$ ,  $d$ : -0.57), "E" (1.08±0.15 vs 1.16±0.20 kW,  $p=0.27$ ,  $d$ : -0.67), Etot (318±53 vs 340±78 kJ,  $p=0.33$ ,  $d$ : -0.57), HRmax (145±17 vs 173±37 beats·min<sup>-1</sup>,  $p=0.16$ ,  $d$ : -0.93) and [La-] (4.1±3.4 vs 6.4±6.6 mmol·l<sup>-1</sup>,  $p=0.26$ ,  $d$ : -0.68). Regarding biomechanics,  $\eta_p$  was higher while using wetsuit (67±14 vs 56±15%,  $p=0.046$ ,  $d$ : 1.65), while SR (26.2±3.27 vs 28.26±3.43 cycles·min<sup>-1</sup>,  $p=0.20$ ,  $d$ : -0.82), SL (3.3±0.6 vs 3.0±0.7 m,  $p=0.14$ ,  $d$ : 0.99) and SI (4.90±1.86 vs 4.25±1.69 m<sup>2</sup>·s<sup>-1</sup>,  $p=0.21$ ,  $d$ : 0.78) were similar between conditions.

**CONCLUSION:**

Despite the similar physiological and technical values found, the higher value on  $\eta_p$  using the wetsuit Speedo Thinswim® could be due to the reduction on hydrodynamic drag, inducing in a decrease in energetic contributions and so higher  $v$  might be reached with the same effort on 400m front crawl.

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**OP-AP07 Team sports****POSITION-RELATED BODY COMPOSITION, SEXUAL MATURATION STATUS AND SOCIOECONOMIC BACKGROUND OF ADOLESCENT FEMALE HANDBALL PLAYERS**

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**INTRODUCTION:**

The study aimed to measure and compare body composition, maturity status and socioeconomic characteristics of adolescent female handball players and analyze the influence of position for the body composition.

**METHODS:**

Body composition (Inbody 770) were investigated in 99 adolescent female handball players (age 15,41 ± 1,81 y) from two Hungarian handball clubs, grouped according to their playing position [goalkeeper (n=16), wing (n=28), left/right back (n=26), middle back (n=15), pivot (n=14)]. Sexual maturation was measured by sexual maturity rating (Tanner-scale) and the age of menarche.

**RESULTS:**

The goalkeepers are significantly higher than wings and middle backs, backs than wings, middle backs and pivots ( $p=0,032$ ) and pivots than middle backs ( $p=0,044$ ). The weight of the goalkeepers are significantly higher than wings; middle backs ( $p<0,001$ ) and backs ( $p=0,027$ ), pivots than wings ( $p<0,001$ ) and middle backs ( $p<0,001$ ), backs than wings ( $p=0,002$ ) and middle backs ( $p=0,001$ ). The skeletal muscle mass of goalkeepers, pivots and backs is higher than wings ( $p<0,001$ ) and middle backs ( $p=0,001$ ;  $p=0,003$ ;  $p<0,001$ ). Both of the Tanner scales are correlated with body fat mass [ $r(97)=0,296$ ,  $p=0,03$ ;  $r(97)=0,236$ ,  $p=0,018$ ] and fat mass of trunk [ $r(97)=0,302$ ,  $p=0,002$ ;  $r(97)=0,251$ ,  $p=0,012$ ]. The development of breasts is correlated with the length of menstrual bleeding [ $r(90)=0,253$ ,  $p=0,015$ ]. Subjective rating of school performance has negative relationship with the development of pubic hair [ $r(99)= -0,220$ ,  $p=0,027$ ], BMI [ $r(98)= -0,281$   $p=0,005$ ], body fat mass [ $r(98)= -0,324$   $p=0,01$ ], and positive with the parental education level [ $r(90)= 0,213$ ,  $p=0,041$ ;  $r(92)=0,274$ ,  $p=0,007$ ]. Subjective rating of wealth has negative correlation with BMI [ $r(98)= -0,212$   $p=0,034$ ] and skeletal muscle mass [ $r(98)= -0,264$   $p=0,008$ ].

**CONCLUSION:**

These findings expand on previous data about the presence of body composition's differences within playing positions in adolescent handball athletes. The sexual maturation status and socioeconomic data can help to understand our athletes background and opportunity for the development both in sport and life.

**THE REALITY OF SMALL-SIDED GAMES IN RUGBY UNION: A CASE FOR SYSTEMATIC APPROACH**

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**INTRODUCTION:**

Small-sided games (SSGs) are prominent in the literature within team sports training due to their assumed concurrent sport-specific technical, tactical, and conditioning benefits. The use of SSGs in rugby, their actual prevalence, and the specific application of SSGs in rugby union is currently somewhat anecdotal. Additionally, the lack of a systematic approach in SSG research limits the ability to make definitive evidence-based recommendations. Therefore, the aim of this research was to investigate the use of SSGs in rugby union, evaluate the scientific evidence regarding these training forms, and adopt a systematic approach towards design variables that differentiate training outcomes.

**METHODS:**

A systematic literature review (PRISMA) and an electronic survey (Qualtrics) were conducted to obtain evidence of both SSG-training practice and research in rugby union. A SSG intervention pilot study was conducted with a selection of talented youth (n=96), to assess the impact of systematic changes in design and player characteristics on acute training outcome variables.

**RESULTS:**

A literature review produced 7 studies that reported on the use of SSGs in rugby union; however, the quality of studies ranged from poor to average. Only one publication studied young players, without reporting effects of SSG design variables. A survey of 106 respondents found that technical skill development (25-28%) and fun (24-30%), and technical skill (21-30%) and physical conditioning (20-35%) formed the main motivation for using SSGs on the lower and higher levels, respectively. 83% of coaches used SSGs every 1-3 sessions. 3 bouts (46%) of 1:1 to 5:1 work-rest ratio SSGs, using 6-14 players, and level-dependent touch (57-64%) and union rules (18-49%) were preferred. When a systematic approach to SSG prescription was taken, perceived exertion (RPE) differences were noted for sex (M: 13.53 ± 2.66 vs. F: 12.84 ± 2.43; p= .074), pitch size (13.54 ± 2.54 (35x50 m) vs. 12.74 ± 2.55 (25x35m); p= .04), and player number (13.90 ± 2.71 (3 v 3) vs. (12.44 ± 2.20 (5 v 5); p < .01).

**CONCLUSION:**

SSGs are prevalent and relevant in rugby union. However, the scientific evidence surrounding these training forms in rugby union is scarce, and their methodological reporting suboptimal. A lack of consistency exists with respect to SSG design, as well as noted differences in application between playing levels. Here we report the first study in youth rugby union regarding the effects of SSG design variables on perceived exertion, demonstrating that lower player numbers and larger pitch sizes likely increase intensity. Important sex differences may also exist that require consideration. Systematic investigation into causal relationships between SSG design variables and conditioning effects within rugby union is warranted to formulate optimal, differentiated, and evidence-based recommendations.

**TRAINING LOAD MONITORING IN AMATEUR RUGBY UNION: A SURVEY OF CURRENT PRACTICES**

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**INTRODUCTION:**

Amateur Rugby Union has an inherent risk of injury that is associated with detrimental effects on player welfare and team performance. Training load (TL) is a modifiable risk factor that, when monitored, may provide strength and conditioning (S&C) coaches with opportunities to reduce the risk of injury. The purpose of this study was to explore TL monitoring practices used by S&C coaches working with male and female amateur adult Rugby Union teams and their rationale for using such.

**METHODS:**

Thirty-three (n = 31 male and n = 2 female) S&C coaches representing 62.2% of the total number of male clubs and 71.4% of female clubs, playing at the highest national amateur level, participated in the study by completing an online survey designed to explore training load monitoring techniques and their rationale for using such. Responses were analysed using frequency and thematic analyses.

**RESULTS:**

72.7% of respondents stated that they monitor TL. The most common method of recording training intensity was the session rate of perceived exertion (sRPE), used in 83.3% of monitoring systems. 33.3% of the S&C coaches surveyed use the sRPE data to calculate the acute:chronic workload ratio (ACWR) as a tool for highlighting when players are at risk of injury. Three higher order themes were highlighted: (a) communication with players (b) support from other staff and (c) limiting factors.

**CONCLUSION:**

This study is the first of its kind to exclusively examine the TL monitoring practices of S&C coaches working with amateur adult Rugby Union teams. Subjective measures are more heavily relied upon in the amateur setting, likely due to ease-of-use, accessibility and low-cost. Session rating of perceived exertion was a very common method of monitoring player TL. Thirty-three percentage of the respondents used ACWR, however, practitioners need to understand its intricacies and limitations before considering whether to incorporate it in their TL monitoring practices. The limited resources available to S&C coaches of amateur teams restrict their TL monitoring practices and clubs may need to give more financial support to their S&C coaches to allow a more effective system to be established. The relationship and communication with players and other coaching staff was a highly valued method of monitoring TL with several S&C coaches stating it is pivotal to the success of their practices. Research examining the TL monitoring practices of professional teams may not always be transferable to the amateur setting and future research should reflect this. Sporting associations should include the most up-to-date research on TL monitoring techniques in their taught courses in order to develop a network of knowledgeable coaches. There is a need in the amateur population for a TL monitoring system that is both attainable and scientifically sound and the information in the current study should aid in achieving this.

**MECHANICAL DEMAND ELICITED BY A CONGESTED SCHEDULE IN ELITE FEMALE ICE HOCKEY**

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**INTRODUCTION:**

Mechanical demand imposed on women ice hockey players has been mainly studied across the course of a single match-play. However, major elite competitions commonly require players to perform successive matches over seven to ten days with no more than 48 h in between. The purpose of this study was to quantify mechanical demand withstood by women ice hockey players over successive international matches against the same opponent team (i.e. standardized opposition level) using inertial-derived player load (PL).

**METHODS:**

Absolute (in a.u.) and relative (in a.u.min<sup>-1</sup>) PL was calculated from 3D-accelerations assessed using embedded accelerometers worn by six elite women ice hockey players during four international exhibition matches performed over five consecutive days. Video-based time-motion analysis (TMA) was used to quantify total effective playing time (excluding benching and time outs), mean effective playing time per shift and number of shifts. Peak PL detection using rolling average was applied to detect the playing phases eliciting peak PL. Differences in mechanical demand within (between the three periods: P1, P2 and P3) and between matches were analysed.

**RESULTS:**

Players performed 21±5 shifts per match and 7±2 shifts per period, resulting in a mean effective playing time of 18.4±5.4 min per match. Mean effective playing time duration per shift was 45.34±26.10 s. Analyses of variance showed a main effect of time on effective playing time per shift ( $P<0.001$ ;  $\eta^2=0.04$ ) with a significant increase in P2 compared to both P1 ( $P<0.001$ ,  $ES=0.46$ ) and P3 ( $P=0.003$ ,  $ES=0.33$ ). While no significant difference was found for PL ( $P>0.74$ ;  $\eta^2=0.04$ ), relative PL significantly decreased ( $P=0.001$ ;  $\eta^2=0.46$ ) from P1 (26.61±0.66 a.u.min<sup>-1</sup>) to P2 (24.24±0.53 a.u.min<sup>-1</sup>;  $ES=1.02$ ) and P3 (24.47±0.30 a.u.min<sup>-1</sup>;  $ES=0.92$ ) with no differences between matches ( $P=0.45$ ;  $\eta^2=0.10$ ). Peak PL also significantly decreased ( $P=0.03$ ;  $\eta^2=0.25$ ) from P1 (0.69±0.02 a.u.) to P3 (0.64±0.02 a.u.;  $ES=0.53$ ) but not between matches ( $P=0.07$ ;  $\eta^2=0.14$ ).

**CONCLUSION:**

While TMA variables are highly dependent on coaching strategy, our results aligned with previous data reported during university women ice hockey matches (1). In the context of standardized opposition (same opponent team), the amount of PL supported by players was constant over consecutive international matches. As previously reported in men ice hockey international matches (2, 3, 4), high-intensity mechanical demand (relative and peak PL) decreased from the first to the last period, indicative of temporary fatigue development. While additional influence factors (money time in P3, increase in shift frequency and playing time for best players) may not be excluded, assessing mechanical demands may help practitioners to monitor players' performance, fatigue development and in turn adjust coaching and training strategies throughout international competitions.

1. Jackson et al. (2016) 2. Brocherie et al. (2018) 3. Douglas & Kennedy (2019) 4. Lignell et al. (2018).

**OFFENSIVE EFFECTIVENESS IN TOP LEVELED EUROPEAN FOOTBALL TEAMS: DIFFERENCES BETWEEN LEVEL OF QUALIFICATION.**

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**INTRODUCTION:**

Goal is one of the most crucial performance indicators in establishing success of both collective and individual level (Mitrotasios et al., 2019). Although an overwhelming number of studies have been conducted to examine goal-scoring actions during various tournaments, Champions League competition seems neglected. The aim of the present study was to analyze goal-scoring indicators during Champions League 2017-18 and evaluate possible variations between different qualification levels.

**METHODS:**

All goals (N=401) from Champions League 2017-18 season were analyzed using video analysis software Lince (Gabin et al., 2012). The 32 teams that competed were sorted into three groups according to their qualification level: a) teams not qualified for round of 16 (R32), b) teams qualified for round of 16 (R16) and c) teams qualified for quarter-finals (R8). The goal scoring indicators gathered were: first goal effect, time of scoring, type of attack, spatial analysis, technical action, type of final attempt and system of play used. A descriptive analysis of data was done for each indicator while to discriminate between the three groups, a one-way ANOVA was performed. Intra-observer and inter-observer reliability calculated with Cohen's Kappa.

**RESULTS:**

During 125 matches teams from R32 scored 3.15±1.52, R16 teams scored 3.45±1.37 and R8 teams scored 3.53±1.50 goals, without any significant differences between the three groups. First goal had significant effect on final result for R16 and R8 teams ( $p<0.05$ ). The majority of goals were scored at the 2nd half of matches ( $p<0.05$ ), inside the penalty area ( $p<0.05$ ), with short passing ( $p<0.05$ ) but no significant differences were evident between groups. The indicator that majorly discriminated the three groups was type of attack; R8 teams scored more goals (51.7%) using counter attacks ( $p<0.05$ ) while R32 and R16 implicated more frequently combinative attacks (61.6% and 66.9%).

**CONCLUSION:**

Results signified that top leveled European teams present similar goal scoring patterns. These findings provide important insights for coaches to design training sessions that reproduce specific tactical scenarios and manipulate specific defensive and spatial constraints in order to improve offensive effectiveness.

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**PHYSICAL FITNESS IN YOUNG FOOTBALL PLAYERS: INFLUENCE OF MATURATIONAL STAGE AND MAXIMAL OXYGEN UPTAKE**

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**INTRODUCTION:**

One of the best ways to discriminate the beneficial effect of sports practice is physical fitness. Physical fitness is understood as the ability of an individual to perform physical activity and is an integrated and effective measure of the body structures and functions. The main exponent of physical fitness is cardiorespiratory fitness, an individual ability to perform long-term physical activity. Different studies in children

and young people have demonstrated that the practice of recreational football for 2-3 days a week improves the musculoskeletal, metabolic and cardiovascular systems. However, the benefits intrinsically associated with regular football practice itself, physical fitness and health indicators could vary depending on different age categories and improve if they also control and improve basic physical variables such as cardiorespiratory fitness. Therefore, the aim of this study was to analyse the relationship between cardiorespiratory fitness (VO<sub>2</sub>max) with different physical fitness variables and nutritional habits in children and young football players.

#### METHODS:

One hundred ninety-four male football players (aged 8-16) from three football sports schools participated in this study. Players were divided into two groups depending on their pubertal state (prepubertal n = 127 and pubertal n = 67). Data on cardiorespiratory fitness (the 20-m shuttle run test), anthropometric measurements, respiratory capacity (forced spirometry), muscle fitness (handgrip strength test) and nutritional habits (Kidmed questionnaire) were collected. Differences between groups were evaluated through two-way ANOVA (prepubertal vs. pubertal and VO<sub>2</sub>max high vs. VO<sub>2</sub>max low). Significant main effects were followed-up by Bonferroni post-hoc procedures. Significance was set at p<0.05.

#### RESULTS:

The results show a direct relationship between low levels of VO<sub>2</sub>max and BMI (prepubertal, +2.78 kg / m<sup>2</sup>; 95% CI: 1.74-3.81; p<0.001; ES: 1.07 and pubertal, + 1.79 kg / m<sup>2</sup>; 95% CI: 0.30-3.29; p<0.001; ES: 0.56), fat mass (prepubertal, + 4.63%; 95% CI: 2.74-6.50 p<0.001; ES: 0.89 and pubertal, + 4.04%; CI 95%: 1.31-6.77; p=0.004; ES: 0.77) and leg fat (left leg, + 1.17%; 95% CI: 0.12-2.22; p=0.029; ES: 0.33 and right leg, + 1.18%; 95% CI 0.092-2.26; p=0.034; ES: 0.32). Similarly, players with lower VO<sub>2</sub>max presented higher values of strength in the prepubertal state (+2.98; 95% CI: 0.23-5.74 p=0.034; ES: 0.41). On the other hand, improvements in respiratory values were seen in the pubertal state with the rest of the parameters when the VO<sub>2</sub>max was increased (p>0.05).

#### CONCLUSION:

Results suggest that the practice of physical and sports activity is an important habit that must be acquired in the prepubertal age in order to consolidate skills in the pubertal age. Moreover, it is important to promote sports policies associated with the development of cardiorespiratory fitness in order to improve physical fitness and healthy habits in active children and adolescents.

### THE EFFECT OF LENGTH SIZES ON BODY COMPOSITION ESTIMATION

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#### INTRODUCTION:

Bioelectrical impedance analysis (BIA) and dual-energy X-ray absorptiometry (DXA) are often used to estimate body composition, nevertheless estimations with these two methods differ. Several factors may cause these differences, for example, nutritional status or various levels of physical activity. Since athletes are usually taller and have lower percent body fat (PBF) and greater lean body mass (LBM) than the average population, it is important to understand the magnitude of these differences. Therefore, the aim of this study was a) to analyze body composition estimations with BIA and DXA in three sports and b) to examine the effect of length sizes on body composition estimation.

#### METHODS:

738 male athletes (15.8±1.4 yrs) from three sports (soccer, basketball, handball) were measured. Anthropometry was performed according to the International Biological Program. Body composition was estimated by BIA (InBody 720) and by DXA (Lunar Prodigy). Differences between the two methods were tested by Bland-Altman analysis and by paired t-test. ANOVA was used for inter-group comparisons. Pearson correlation and multivariate linear regression was used to look the relationship between segmental lean body mass and length size.

#### RESULTS:

BIA consistently underestimated PBF and overestimated LBM than DXA. The magnitude of the differences between the two methods varied among the examined sports. Handball (ΔPBF=8.3±2.4 %; ΔLBM=-5.0±2.1 kg) and basketball players (ΔPBF=8.8±2.3 %; ΔLBM=-5.3±1.8 kg) had significantly larger differences between the two methods than soccer players (ΔPBF=6.4±2.2 %; ΔLBM=-3.1±1.4 kg). There was negative correlation between differences in segmental LBM estimation and length sizes (trunk length, upper extremity length, lower extremity length). The highest correlation was found for lower extremity (r=-0.4). Longer lower extremity resulted in greater difference in LBM estimation. All length sizes together explained the 31% of the total variance of the difference in LBM estimation. Athletes, whose lower extremity length was longer than the P97 of the normative data from the Hungarian population showed a drastic increase in LBM estimation between BIA and DXA.

#### CONCLUSION:

The differences between the sport disciplines are most probably attributed to body size differences. LBM estimations with BIA are based on a 5-cylinder model, the length of which is estimated from body height assuming standardized body proportions. However, athletes quite often demonstrate other than standardized body proportions. Cylinder length has an effect also in the estimation of total body water (used in LBM calculation); the increase of the former exponentially increases LBM estimation, which eventually results in larger differences between the two methods. Body composition estimation with BIA needs to be carefully interpreted in athletes with extreme length sizes, especially, with basketball players.

Keywords: young athletes, DXA, bioimpedance method

### EFFECT OF MATCH LOCATION ON MATCH RUNNING PERFORMANCE OF AN ELITE SOCCER TEAM

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#### INTRODUCTION:

Game location is an influencing factor affecting in isolation or interactively with other situational variables (playing position, game result or opposition level) match running performance of elite soccer players (1,2). The purpose of the present study was to investigate the effect of match location on match running performance of an elite Greek soccer team during a competitive season.

#### METHODS:

Sixteen home and twelve away Greek Super League (highest level) matches played by a professional soccer team were analyzed during the 2018-2019 season using a Polar Team Pro tracking system based on GPS technology. Only data for players completing entire matches were included in the analysis equaling 157 observations. The following match physical performance measures were assessed: total distance (TD),

high speed running distances (HSR; distance covered with more than 19 km/h), maximum speed (MS) and the number of sprints (NrSP; distance covered with more than 25 km/h).

**RESULTS:**

Significantly ( $p < 0.05$ ) more HSR distances and NrSP were observed in home (HSR:  $837 \pm 313$ m; NrSP:  $15 \pm 7$ ) compared to away (HSR:  $725 \pm 276$ m; NrSP:  $12 \pm 7$ ) matches. No significant differences were found on TD and MS.

**CONCLUSION:**

The findings of the present study have shown that match running performance during a competitive season of an elite soccer team was influenced by match location. Previous investigators have reported that home teams covered a greater low-intensity distance than away teams. Possible reasons are crowd effects, travel effects, tactical and psychological factors (1).

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**INDIVIDUAL HEART RATE VARIABILITY ANALYSIS DURING TRAINING CAMPS OF AN EUROPEAN NATIONAL SOCCER TEAM**

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**INTRODUCTION:**

Professional soccer players have shown impairments in physiological and performance measures after playing soccer matches [1], especially during congested fixture periods. Heart rate variability (HRV) can be used to monitor cardiac autonomic responses after playing a soccer match [2]. Analyses can be performed using group or individual changes. Individual changes could be of potential interest in professional soccer players during training camps for national soccer teams [3]. The purpose of this study was to compare whether analysis of individual daily HRV could detect changes in cardiac autonomic responses during training camps for national soccer teams.

**METHODS:**

During two different training camps, 34 professional soccer players were monitored daily over 9 days, using heart rate monitors. Players were divided into First Eleven (those who participated in the main squad) or Reserves (others). Daily HRV (ln-rMSSD) was individually analyzed using the biological variation (SWC= 0.5 times individual standard deviation) and random error (TE) of days prior to first match (match day (MD) minus 4 to MD1) to establish a trivial band. Players' responsiveness was classified as High-, Low- or Non-response depending on individual changes above (High), in (Non) or below (Low) the trivial band. Distribution of individual responses were classified using a 3x2 contingency table.

**RESULTS:**

There were substantial daily individual HRV changes after playing a soccer match, regardless of the group. Only at MD+1 were found a significant different between-groups distribution in the responsiveness classification (High-responders, First Eleven= 10% vs Reserves= 90%,  $p=0.012$ ). The responsiveness classification of High-, Low- and Non-responders for each day after match was: MD+1, First Eleven= 5.9/64.7/29.4% and Reserves= 50/27.8/22.2%; MD+2, First Eleven= 47.1/29.4/23.5% and Reserves= 61.1/27.8/11.1%; MD2, First Eleven= 58.8/23.5/17.7% and Reserves= 33.3/27.8/38.9%, respectively.

**CONCLUSION:**

In conclusion, individual daily HRV analysis showed a high variation in individual responses, even if players were Reserves, after playing a soccer match. The individual analysis method used was able to differentiate between High-, Low- and Non-responders in a national soccer team after playing soccer matches during training camps, using the TE and SWC to establish a trivial band (no change). This classification was observed even in Reserves players, where the only difference in the responsiveness distribution with First Eleven players was in the High-responders group, the next day after playing a soccer match. This analysis can be performed using changes from day to day during international soccer national team competitions to detect possible acute states of fatigue in professional soccer players.

**THE EFFECTS OF A 8-WEEK PLYOMETRIC TRAINING PROGRAM ON JUMP AND AGILITY PERFORMANCE IN ELITE BASKETBALL PLAYERS**

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*NUI GALWAY*

**INTRODUCTION:**

Plyometric training has been shown to increase muscle power, running economy, and performance in athletes. Performance in basketball, requires athletes to rely on anaerobic power to fuel performance. Skills such as shooting, rebounding, and shuffling require power, and thus successful basketball performance relies on the ability to generate power. Performance in basketball can therefore be greatly increased through training that not only increases anaerobic capacity but also increases strength, speed and agility. More specifically, training that improves jumping ability is extremely crucial for basketball players. In fact vertical jump height has been shown to be the strongest predictor of agility and performance in elite college basketball players.

While strength programs may be most beneficial for beginners to achieve increases in their jump height, more elite athletes can benefit from programs which train the contractile and neural components of jumping. Plyometric training (PT) has gained popularity over the past few decades and has been utilized as a tool to help enhance jump performance. PT is defined as a type of training in which high intensity eccentric loading is immediately followed by a concentric contraction. Further, PT trains the stretch-shortening cycle (SSC) of the muscles and tendons. The SSC is involved in jumping and consists of the eccentric lengthening of the muscles during the downward motion, followed by concentric action in the upward phase. It has shown significant improvements in performance in sports where explosive power is needed. Therefore the purpose of this study was to determine if a 8 week plyometric training in addition to the athletes usual training routine, would lead to improved jump height, speed, agility and performance in basketball players.

**METHODS:**

Eight college level Irish basketball players participated in the PT training program. The remaining 5 basketball players were assigned to the control group. Participants were tested for jump height with the countermovement jump with arm swing, squat jump, and 18-cm depth jump; participants were also tested for reactive strength index (RSI) and contact times during the depth jump. Agility was assessed using a unique agility drill. Speed was assessed by the sprint test.

**RESULTS:**

After the 8 weeks intervention of PT, participants significantly improved their RSI during the depth jump ( $p < 0.05$ ). A trend demonstrated that participants decreased their contact time ( $p = 0.10$ ), changes in jump height and agility also showed improvements with statistical significance ( $p < 0.50$ )

#### CONCLUSION:

In summary, the addition of 8 weeks plyometric training to the usual in-season basketball regimen of the basketball players enhanced their jump height, speed and agility. The plyometric program helped the participants increase their RSI during depth jumps. Trends also revealed that the plyometric program helped the participants increase their jump heights and decrease their contact time for the depth jump. This increase in performance may have been mediated by significant improvements in muscle strength and power, which warrants further investigation.

## OP-AP08 Winter sports I

### FLIGHT STABILITY CONTROL MECHANISM OF SKI JUMPING IN LATERAL WIND ENVIRONMENT

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#### INTRODUCTION:

Wind is not only closely associated with the discussion of fairness in ski jumping, but also very important to flight safety. Flight stability is essential for performance and safety in ski jumping, and mainly involved several factors, such as environmental wind and flight posture. However, the flight stability control mechanism of ski jumping in lateral wind environment remains unclear. The purpose is to determine the flight stability control mechanism of ski jumping in lateral wind environment.

#### METHODS:

The aerodynamic characteristics of ski jumping during flight under different lateral wind and yaw angles are predicted by numerical simulation of computational fluid dynamics, and the effects of the above two elements on flight stability are compared and analyzed. The jumper and skis were regarded as a multi-body system, and partially averaged Navier-Stokes turbulence model was used to simulate aerodynamic characteristics of the system based on a general flight attitude and then the forces and torques were obtained. The lateral wind speed involved in the numerical prediction includes 1.5 m/s, 3 m/s, 4.5 m/s and 7.5 m/s, and the flight yaw angle involved includes 2.5°, 5° and 7.5°.

#### RESULTS:

When lateral wind speed is small (less than 3 m/s), yaw force, yaw torque and rolling torque are small and almost negligible, and when lateral wind speed is larger than 4.5 m/s, yaw force, yaw torque and rolling torque are more obvious. When wind speed is 4.5 m/s and 7.5 m/s, yaw force, yaw torque and rolling torque are 9.5 N and 26.3 N, 2.3 Nm and 6.3 Nm, 2.8 Nm and 7.8 Nm, respectively. When yaw angles are 2.5°, 5° and 7.5°, yaw force, yaw torque and rolling torque are 6.8 N, 12.9 N and 21.9 N, 2.5 Nm, 5.0 Nm and 6.8 Nm, 2.7 Nm, 5.7 Nm and 8.3 Nm, respectively.

#### CONCLUSION:

When wind speed is 4.5 m/s and yaw angle is 2.5°, yaw force, yaw torque and rolling torque results of these two conditions are close to each other. Similarly, when wind speed is 7.5 m/s and yaw angle is 7.5°, yaw force, yaw torque and rolling torque results of these two conditions are close to each other. The larger lateral wind can have a significant adverse effect on flight stability control of ski jumping, but it is possible to compensate or even eliminate this adverse effect by taking the appropriate flight yaw angle. The flight stability control mechanism of ski jumping in lateral wind environment can provide effective auxiliary support for on-the-spot prediction and decision-making, and also provide scientific guidance for flight stability control and technical training for athletes.

### ASSESSMENT OF PHYSIOLOGICAL PARAMETERS IN COMPETITIVE SKI MOUNTAINEERING

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#### INTRODUCTION:

Ski mountaineering (SKIMO) is not only performed as a leisure activity, but also as a growing competitive sport. While interest and performance increase, in-race measurements are often restricted to heart rate analysis and performance determining parameters are not clear. Literature reports SKIMO to be one of the most strenuous endurance sports, comparable to cycling, 10 km running or cross-country skiing (Duc et al., 2011; Fornasiero et al., 2018; Gaston et al., 2019). The aim of this study was to determine the physiological response during racing and detect performance related variables from both, in-lab tests and during racing.

#### METHODS:

21 male athletes participated in the study and were stratified in two performance groups. Elite ( $n=8$ ;  $VO_{2max}=71.2\pm 6.8$ ) and subelite ( $n=13$ ;  $VO_{2max}=62.5\pm 4.7$ ) athletes performed two testing sessions. One was an in-lab ramp protocol on the treadmill to obtain physiological capabilities. And the second session was a simulated vertical race in the field (540 m elevation gain). Measuring setup was the same for both sessions, including a heart rate belt, a wearable metabolic system (K5, Cosmed, Italy), a SKIMO specific IMU (Pomoca, Switzerland) and analysis of blood lactate samples (Biosen C-line, EKF, United Kingdom).

#### RESULTS:

Data analysis focused on the comparison of the two performance groups, with respect to a level of significance  $p < 0.05$ . The lab test revealed significant differences between the groups for  $VO_{2max}$  ( $p=0.003$ ),  $VO_2$  at the ventilatory threshold 2 ( $p=0.005$ ) and for maximum speed they reached in the end of the ramp protocol ( $p < 0.001$ ). Field performance revealed differences in race time (27:15 min vs. 32:31 min;  $p < 0.001$ ), average  $VO_2$  during the simulated race ( $p=0.046$ ) which reached on average 82% of  $VO_2$  max reported from the lab test and mean ventilation ( $p=0.049$ ). No difference was found for peak lactate after the simulated race (5 measurements within ten minutes) and mean heart rate during the simulated race. During the simulated race average heart rate reached  $92\pm 1.8\%$  of maximum heart rate without any difference between the performance groups.

#### CONCLUSION:

The presented findings are concordant with literature and suggest SKIMO as one of the most strenuous endurance sports. For the first time in SKIMO,  $VO_2$  was measured in the field and not calculated. Since there was no difference in  $VO_2$  and heart rate relative to the maximum values, the individual relative strain was the same for both performance groups. Elite athletes showed their superiority in a higher absolute  $VO_2$  during both the field test, as well as during the lab test. Furthermore, a trend was found that BMI is lower in elite athletes which

improves their power to weight ratio. Especially velocity and VO<sub>2</sub> at ventilatory threshold 2 seem to be crucial and performance determining parameters in performance diagnosis.

### **ENERGY AVAILABILITY AND PHYSICAL PERFORMANCE IN YOUNG FEMALE CROSS-COUNTRY SKIERS DURING A TRAINING CAMP**

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#### **INTRODUCTION:**

A sufficient energy and nutrient intake is one of the key components optimizing athletes' performance, recovery, training adaptation and health (1). Nevertheless, the knowledge about the nutrition of the cross country (XC) skiers is still limited to few studies (2). Therefore, the aim of this study was to evaluate if female XC-skiers meet their energy needs at home training circumstances and during a training camp and how that affects their performance during the training camp.

#### **METHODS:**

19 female skiers (age 16.7±0.7) from Finnish Ski Association's under 18 years old national team filled food and training logs (2 days) from 2 to 12 days before and during a 5-day training camp. Daily energy intake (EI), exercise energy expenditure (EEE) and energy availability (EA) were calculated. Fasting blood samples (hemoglobin (Hb), leptin (LEP), triiodothyronine (T3), insulin (INS), insulin-like growth factor 1 (IGF-1), glucose (GLU)) and anthropometric measurements were taken in the morning of the first (PRE) and the last day of the camp (POST). Performance tests (4 x 4min submaximal treadmill running, counter movement jump (CMJ) and reactive jump (RJ) on the force plate) were performed similarly. Blood lactate (LA), heart rate (HR) and Rating of Perceived Exertion (RPE) values from the end of the treadmill test, jump height from the CMJ and 2 best jumps average power from the RJ were used in the analysis.

#### **RESULTS:**

Daily EEE (892 ±255 vs. 1598±208 kcal, p<0.001), EI (2586±636 vs. 3653±1057 kcal, p<0.001) and EA (33.4±9.6 vs. 39.8 ± 16.8 kcal/kg fat-free mass, p=0.060) were lower before than during the camp. HR (-3.1±0.5%, p<0.001), HR/RPE ratio (-6.4±1.5%, p<0.001), LA/RPE ratio (-11.6±4.3%, p<0.05) and CMJ (-2.2±1.0%, p<0.05) decreased and RPE (4.0±1.7%, p<0.05) increased from PRE to POST. Concentrations of Hb (-4.4±0.7%, p<0.001), LEP (-21.6±5.3%, p<0.01), T3 (-5.0±2.3%, p<0.05), INS (-17.5±7.4%, p<0.05) and IGF-1 (-6.4±3.2%, p=0.086) decreased and GLU concentration increased (4.2±1.8%, p<0.05) from PRE to POST. Lower EA during the camp correlated with larger decrease in LA (r=0.51, p<0.05), LA/RPE (r=0.53, p<0.05) and RJ (r=0.47, p<0.05). Changes of EA correlated with changes of IGF-1 (r=0.49, p<0.05).

#### **CONCLUSION:**

This study showed association between non-controlled real-life EA, athletic performance and hormonal function. Female skiers were able to compensate higher EEE during the camp with higher EI. Changes in blood and performance variables may indicate overreaching during intensified training period. However, these changes may be affected by EA. Furthermore, higher EA during a camp may reduce the decrease of anabolic hormones, like IGF-1. Thus, adequate EA may be considered as an important factor for optimizing recovery, adaptation and training quality during intensified training period.

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### **FORWARD ACCELERATION DURING ROLLER SKIING ON TREADMILL CALCULATED BY CONSIDERING FORCE AND CENTER OF MASS**

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#### **INTRODUCTION:**

Propulsive force in cross-country (XC) skiing has been defined as the forward direction component of the three-dimensional (3D) resultant reaction force from skis and poles acting on skiers. The position of COM of skiers relative to the direction of the resultant force from skis and poles has been taken into consideration while calculating the propulsion in XC2, but the full applicability of that method has not been investigated. The aim of this study was to use this method for the V2 skating technique on treadmill skiing.

#### **METHODS:**

9 experienced male skiers (Age:28.2 ± 7.4 years, Height: 181.3 ± 6.1 cm, Weight: 77.5 ± 9.3 kg) participated in this study. Vicon system (Vicon, Oxford, UK) was used to record the three-dimensional trajectories of 61 reflective markers while subjects were roller skiing on a treadmill. Two custom-made 2D force measurement bindings (University of Jyväskylä, Finland) for XC skiing and two custom-made pole force sensors (VTT, Kajaani Finland) for XC skiing were used to measure force generated from skis and poles. Fref was the force in skiing direction and acting at the COM determined from 3D motion capture data (Fref=ma). Fnet was the force calculated only by considering ground reaction force (GRF) and the position of the skis and poles. Fpro was the force in skiing direction at COM calculated from force and motion capture data. Coefficient of multiple correlation (CMC) was calculated to determine the similarity between Fref and Fnet, and the similarity between Fref and Fpro.

#### **RESULTS:**

The mean Fref of 8 continuous skiing cycle was 0 and the mean Fpro as well as mean Fnet were significantly greater than mean Fref (p < 0.001). The mean Fpro was significantly smaller than the mean Fnet, which was closer to the mean Fref. The similarity between Fref and Fpro (CMC Value: 0.831 ± 0.035) was significantly greater than similarity between Fref and Fnet (CMC Value: 0.319 ± 0.059) (p < 0.001). The maximum and average differences between Fref and Fnet were significantly greater than that between Fref and Fpro (p < 0.001, p < 0.001).

#### **CONCLUSION:**

Conclusion: The similarity between Fref and Fpro was similar to the result of the previous study when the method was used in the V2A technique on snow. The results of this study indicated that COM acceleration could be calculated from combined ski and pole force in V2 technique while roller skiing on a treadmill. The propulsive force (Fnet) calculated only by considering GRF and the position of the skis and poles overestimated the acceleration of COM when compared to motion data.

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### **AERODYNAMIC SIMULATION OF SKI-JUMPING CONSIDERING DYNAMIC POSTURE CHANGE**

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#### **INTRODUCTION:**

In competitive Ski-Jumping, the take-off and flight phases strongly influence the performance of an athlete. Take-off in ski jumping involves rapidly transitioning from the crouching position to the flying position. It is generally considered that the aerodynamic characteristics of the take-off phase are strongly correlated with the flight distance. To the best of authors' knowledge, a dynamic unsteady aerodynamic analysis of the take-off motion has not been carried out by any prior research. Clarification of the aerodynamic characteristics of the take-off motion of an athlete can provide valuable information that can help in improving the competitiveness of an athlete. In this study, we experimentally obtained the take-off motion over multiple jumping trials by the same athlete and carried out numerical simulations of this dataset for aerodynamic analysis. The aerodynamic characteristics obtained from the results of the numerical simulation are compared with flight distance of each jumping trial to clarify the relationship between the two.

#### **METHODS:**

The take-off motion kinematics of the jumper (height: 1.62m, weight 52kg, age: 18 years old) were obtained over three jumping trials. The motion measurement was carried out using a suit fitted with inertial sensors and a global navigation satellite system (GNSS) sensor. The inertial sensors enabled detailed tracking of the jumper's body motion, and the GNSS sensor is used to obtain the overall trajectory of the jumper during a ski jump trial. The motion capture data from the motion sensor was coupled with the body geometry CAD data of the jumper to generate a CAD geometry based virtual ski-jump model using which the computational fluid dynamics (CFD) simulations were carried out. For the CFD simulations an in-house solver, CUBE, is used which solves the mass and momentum conservation equations using a finite volume method. The solver is built on a hierarchical Cartesian meshing method known as building cube method (BCM) which enables fine-grained accurate solution of the flow around the jumper. An immersed boundary method is used to represent the jumper model to model the complex motion of the jumper.

#### **RESULTS:**

The flight distance of the three trials were: (1) 112m, (2) 90m, (3) 113m. In order to quantify this reason for the difference between the flight distance of trials 1,3 and trial 2 we analyzed the lift-drag ratio and the flow features around the jumper. We found that the lift-drag ratio of trials 1,3 was significantly higher than that of trial 2. Furthermore, we also found that qualitative difference in the wake structure of the trials 1,3 and trial 2.

#### **CONCLUSION:**

CFD simulations were carried out to analyze difference in flight distance of three jumping of an athlete. The results of the simulations showed that there is a quantitative difference in lift-drag ratio and qualitative difference in the wake signature of the successful and failed attempts.

### **TRAINING METHODS AND INTENSITY DISTRIBUTION OF YOUNG ELITE ENDURANCE ATHLETES: A TWO-YEAR LONGITUDINAL STUDY**

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#### **INTRODUCTION:**

The aim of daily training in endurance athletes is to maximize development of physiological adaptations and improve performance, yet the organization of training methods are heavily debated in senior athletes. Furthermore, studies investigating training organization among junior athletes in a longitudinal perspective are lacking. Therefore, the aim of this study is to describe training characteristics and development of successful junior XC-skiers and biathletes over a two-year period.

#### **METHODS:**

Eight elite junior XC-skiers and biathletes (6 males; 16.3±0.3y, 61.5±5.2mL·min<sup>-1</sup>·Kg<sup>-1</sup> VO<sub>2</sub>max, 2 females; 16.5±0.4y, 51.5±0.7 mL·min<sup>-1</sup>·Kg<sup>-1</sup> VO<sub>2</sub>max) reported two years of day-to-day training during their junior career. Training data were logged in an online database and systemized into training forms, exercise modes and intensity distribution; low-intensity training (LIT) defined as below first lactate threshold (LT1), <80%HRmax and <2mmol·L<sup>-1</sup> [La<sup>-</sup>]; moderate-intensity (MIT) between LT1 and second lactate threshold (LT2), 80-88%HRmax and 2-4mmol·L<sup>-1</sup> [La<sup>-</sup>]; high-intensity (HIT) above LT2, >88%HRmax and >4mmol·L<sup>-1</sup> [La<sup>-</sup>]. All athletes underwent standard physiological testing two times per year, including body composition measurements (via dual-energy X-ray absorptiometry) during the two-year period. To assess differences between y1 and y2, athletes were treated as one group and Welch's test for unequal variances were used.

#### **RESULTS:**

VO<sub>2</sub>max improved from y1 to y2, with a 13% increase. Annual training volume (h/year) increased by 10% from y1; 507±78h to y2; 556h±48. Endurance training contributed 88% of total training volume, while strength- (41h±11 y1, 44±10h y2) and speed-training (6h±5 y1, 10±6h y2) contributed 8 and 1-2% of total training every year. Endurance training increased from 445±70 to 493±47h, hereby total LIT volume was 418±71h in y1 and 451±57h in y2, an increase of 8%. Total HIT volume increased by 20% from 18±9h to 21.6±6h from y1 to y2, however absolute HIT-volume remained stable. Endurance training consisted of 93% LIT, 3% MIT and 4% HIT annually and remained constant. Over the two-year period, 57% was sport-specific (skiing or roller-skiing), while 43% was general training (running, biking, strength, etc.). Height, body mass and fat-free-mass increased from y1 to y2, whereas fat-percentage and BMI remained stable.

#### **CONCLUSION:**

The training characteristics of nationally competitive junior skiers conforms to previously reported patterns in intensity distribution in senior athletes. Although total training volume is not comparable to seniors, substantial increases occur every year, in combination with physiological performance. This study highlights the relevance of appropriate dose of training volume and quantification of intensity distribution. The importance of a high training volume, containing large quantity of LIT combined with two-three HIT-sessions per week, seems to be a key to successful endurance training and performance development in junior athletes.



## BIOMECHANICAL AGREEMENT BETWEEN DIFFERENT TYPES OF IMITATION JUMPS AND HILL JUMPS IN SKI JUMPING

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### INTRODUCTION:

Even though the take-off in ski jumping is decisive, athletes only have a very limited number of training trials on the actual ski jump to practice under real ski jump conditions. Hence, various forms of imitation jumps aiming to mimic the hill jump are performed during daily training. These imitation jumps should therefore resemble the kinematic pattern of hill jumps appropriately. The aim of the present study was to compare imitation jumps with real ski jumps. A number of biomechanically relevant parameters were selected as target criteria.

### METHODS:

Nine professional ski jumpers performed imitation jumps in a laboratory setting. Additionally, hill jumps during a championship two days later were recorded. Imitation jumps were selected based on the typical inrun position. Imitation jumps included stationary jumps as well as jumps from a rolling device, each with and without ski jumping boots. On the rolling device, a further distinction was made between trials where athletes were caught by a coach or had to abort the jump after the take-off. This led to six different modalities of imitation jumps. A three-dimensional kinematic analysis of the take-off was assessed to identify the following biomechanical criteria: maximal vertical take-off velocity, maximal knee extension velocity, maximal forward directed angular momentum and anterior shift of the center of mass. A mixed-effect model was applied to compare the imitation jumps with the hill jumps. To analyse the agreement between imitation jumps and hill jumps, a Bland-Altman analysis was carried out for each parameter.

### RESULTS:

Except the vertical take-off velocity, for all kinematic criteria we could identify an imitation jump that is not statistically different to the hill. Imitation jumps from a rolling platform show better agreement than stationary jumps and besides the anterior shift of the center of mass all parameters were best resembled via an imitation jump where the athletes wore ski jumping boots. The modality of the imitation jump has a main effect on every biomechanical criteria ( $p < .01$ ).

### CONCLUSION:

The opportunity to generate shear forces and the high friction in stationary imitation jumps is a considerable difference between take-off in imitation jumps and hill jumps. Ski jumping boots limit the possibility of the plantar flexor muscles to generate power. This leads to better agreement with the hill for vertical take-off velocity and knee extension velocity. Additionally, athletes can only generate an angular momentum not different to the hill in imitation jumps with a catch by a coach. Therefore, non-hill take-off training should be performed with complex imitation jumps to mimic the actual ski jump. This requires a rolling device, ski jumping boots and a catch by a coach. The present study provides novel information about the similarity between imitation jump modalities and real hill jumps which is highly relevant for coaches and athletes in order to effectively design their training programs.

## COMPARISON OF SHOOTING TECHNICAL FACTORS BETWEEN FEMALE AND MALE BIATHLETES

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### INTRODUCTION:

Earlier studies in biathlon standing shooting have revealed that body sway is related to rifle stability and associates to shooting accuracy (1, 2). However, discrepant findings exist about the effect of vertical and horizontal rifle sway on shooting accuracy (3). In addition, shooting accuracy in standing position tends to be slightly higher for TOP5 females (85 vs 82%) compared to males but no sex differences in shooting technical factors have been reported earlier. The present study aimed to compare how different shooting technical factors associates to BIA shooting performance between female and male biathletes.

### METHODS:

17 female (22 (4) yr) and 16 male (22 (5) yr) Swedish biathletes including World Championship and Olympic medal winners were recruited. Shooting performance and technical factors were first determined at rest (2x5 shots), followed by 10 min warm-up and maximal double poling ergometer test for 1000 m to achieve the maximal heart rate (HRmax). After 10 min of passive recovery, the biathletes performed 2x5 min double poling exercise at 92 (1) % of the HRmax to simulate the physical exercise effort during biathlon competition (BCS) followed by 5-shots after both exercise bouts. Opto-electronical device was used to assess shooting accuracy (group size of the shots, GS, mm; average shooting result, RES, points) as well as horizontal (HOR) and vertical (VER) rifle speeds (mm/s), and triggering pressure (TRIG, %) during the last 0.2 s before each shot. Shooting was performed only in standing position. The effect of sex (female and male) and shooting condition (rest and exercise) was evaluated using 2-way ANOVA. Associations between shooting technical factors and shooting performance (GS and RES) were determined using Pearson's correlation coefficient. Data is presented as mean (standard deviation).

### RESULTS:

Shooting performance was higher for females at rest (GS 26 (9) vs 32 (11) mm; RES 7.2(1.0) vs 6.6 (1.4)) and after exercise (GS 26 (6) vs 32 (5) mm; RES 6.6 (1.1) vs 5.5 (1.5)) (both  $p < 0.01$ ). RES also decreased from rest to exercise in both sexes ( $p < 0.01$ ). HOR ( $p < 0.01$ ) and VER ( $p < 0.001$ ) increased from rest (HOR 8 (3) vs 10 (3) mm/s; VER 7 (2) vs 8 (3) mm/s) to exercise (HOR 11 (5) vs 13 (3) mm/s; VER 9 (2) vs 12 (2) mm/s) in both sexes but were lower for females (both  $p < 0.05$ ). No differences in triggering pressure were observed between shooting conditions or sexes. At rest, HOR and VER correlated significantly with GS ( $r = 0.67 - 0.78$ ,  $p < 0.01$ ) and RES ( $r = -0.59 - -0.87$ ,  $p < 0.05$ ) in both sexes. After exercise, only VER was associated to GS ( $r = 0.54$ ) and RES ( $r = -0.61$ ) for females whereas only HOR was associated to GS ( $r = 0.80$ ) and RES ( $r = -0.66$ , all  $p < 0.01$ ) for males.

### CONCLUSION:

Females demonstrated slower rifle speed before triggering at rest which was also related to higher shooting performance compared to males. Different rifle motion pattern between sexes were observed during BCS which might explain the difference in shooting performance between sexes.

## EFFICIENCY AND CYCLE CHARACTERISTICS ACROSS SUB-TECHNIQUES IN ROLLER-SKI SKATING

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### INTRODUCTION:

Cross-country skiers perform numerous transitions between sub-techniques, depending on the incline, speed, and environmental conditions. When using the skating style, skiers mainly transition between gear 2 (G2), gear 3 (G3), and gear 4 (G4). The main aim of the study was to compare GE of these three skating sub-techniques on the preferred incline-speed combinations. The secondary aim was to examine if differences in GE between techniques are associated with differences in cycle rate (CR) and cycle length (CL) between techniques.

#### METHODS:

Thirteen well-trained male XC skiers and biathletes (peak oxygen uptake (VO<sub>2</sub>peak) 69.5 ± 3.7 mL·kg<sup>-1</sup>·min<sup>-1</sup>) completed a 5-min roller skiing warm up and in random order three 4-min submaximal exercise bouts at a low intensity using G2 (12% incline, 6 km·h<sup>-1</sup>), G3 (5% incline, 10 km·h<sup>-1</sup>), and G4 (2% incline, 15 km·h<sup>-1</sup>), three bouts at a slightly less low intensity (G2 at 7 km·h<sup>-1</sup>, G3 at 12 km·h<sup>-1</sup>, G4 at 18 km·h<sup>-1</sup>), three bouts at a moderate intensity (G2 at 8 km·h<sup>-1</sup>, G3 at 14 km·h<sup>-1</sup>, G4 at 21 km·h<sup>-1</sup>), and finally three exercise bouts at a slightly higher moderate exercise intensity (G2 at 9 km·h<sup>-1</sup>, G3 at 16 km·h<sup>-1</sup>, G4 at 24 km·h<sup>-1</sup>). In between bouts skiers rested ~2-2.5 min. Work rate (WR) was calculated as the sum of the power against gravity and friction. Average respiratory data of the final minute of each bout were used to calculate metabolic rate (MR). For each technique the WR-MR relationship was determined, as it reflects GE. Repeated measures ANOVA was used to investigate the effect of technique on the y-intercept and slope of the WR-MR relationship. Average CR and CL were determined during the last minute of each bout using IMUs. Correlation coefficients were determined between differences in CR or CL between techniques and differences in GE between techniques.

#### RESULTS:

Technique significantly influenced the y-intercept ( $p=0.004$ ) and slope ( $p<0.001$ ) of the WR-MR relationship. The y-intercept differed significantly between G2 (70.1±76.8 W) and G3 (157.5±101.7 W,  $p=0.009$ ) and G3 and G4 (60.7±99.2 W,  $p=0.009$ ). The slope differed significantly between G2 (5.61±0.37) and G3 (5.93±0.52,  $p=0.03$ ), G2 and G4 (7.68±0.72,  $p<0.001$ ), and G3 and G4 ( $p<0.001$ ). None of the correlation coefficients between differences in CR or CL and differences in GE between sub-techniques were considered larger than moderate (i.e.  $> r=0.50$ , all  $p>0.05$ ).

#### CONCLUSION:

The sub-techniques, when performed at the preferred incline, result in different metabolic rates irrespective of speed and thus work rate, with G2 (12%) outperforming G3 (5%), which outperforms G4 (2%). This is in line with other studies indicating that skiing at steeper inclines is energetically advantageous if external work rate is the end goal. Although, it has previously been suggested that differences in CR could explain some of the differences in GE, the current study found no significant correlations between differences in CR and differences in GE.

### THE RELATIONSHIP BETWEEN THE LOWER EXTREMITY STRENGTH AND JUMPING PERFORMANCE IN COMPETITIONS ON CHINESE MALE ELITE FIGURE SKATERS

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#### INTRODUCTION:

Jumping performance is becoming an increasingly important issue in figure skating competitions. The demand for more jumping skills has resulted in an increased demand for lower extremity strength, power, and "power endurance" to achieve high-difficulty skills while fatigued. But the research about the strength characteristics of figure skaters and the relationship between strength and on-ice performance is inadequate. The research aimed to 1) analyze the characters of the lower extremity strength of Chinese male elite figure skaters; 2) investigate the relationship between pre-season strength and jumping performance in competition.

#### METHODS:

Eight nationally ranked Chinese male figure skaters volunteered for this study ([M±SD] n=8, height 173.8±5.0 cm, weight 64.3±4.6 kg, age 20.1±3.1 yrs). All the athletes were turning left in jumping, so their right leg was landing leg. The dynamic strength of the hip and knee were measured at angular velocities of 60°/s (Isomed2000, ROM 90-10 degrees) in pre-season. Competition Results were collected from the first national competition after testing. The short program has 3 jumps, the long program has 8 jumps. The total score is the sum of jump scores respectively. The base score is the standard score, and the real score is the judge score (include the GOE).

#### RESULTS:

The left hip extension strength (4.91±0.76 Nm/kg) was significantly higher than the right (4.72±0.81 Nm/kg,  $p=0.005$ ). The right knee extension strength (3.01±0.38 Nm/kg) was significantly higher than the left (2.80±0.42 Nm/kg,  $p=0.016$ ). The total base score of jumps in short program (22.12±2.02) was highly negatively correlated to the right hip flexion strength ( $r=-0.778$ ,  $p=0.023$ ). The total real score of jumps in short program (20.05±5.19) was highly positively correlated to the max rate of force development (RFD, 50-100ms) of the right hip extension ( $r=0.788$ ,  $p=0.020$ ). The total base score of jumps in long program (48.13±12.51) was highly negatively correlated to Flex/Ext ratio of max RFD of the right hip ( $r=-0.760$ ,  $p=0.029$ ), and highly positive correlated to Flex/Ext ratio of max RFD of the left knee ( $r=0.890$ ,  $p=0.003$ ). The total real score of jumps in long program (44.76±12.64) was highly negatively correlated to Flex/Ext ratio of max RFD of the right hip ( $r=-0.825$ ,  $p=0.012$ ), and highly positive correlated to Flex/Ext ratio of max RFD of the left knee ( $r=0.916$ ,  $p=0.001$ ).

#### CONCLUSION:

The results suggest: 1) The hip extension muscle in the jumping leg (left leg) and the knee extension muscle in the landing leg (right leg) are stronger than the counterparts, which indicate they are probably more active than the counterparts in training and competition; 2) Improving the rapid force capacity of hip extension muscle and relaxing the hip flexion muscle of landing leg (right leg) may contribute to a high-quality jump in competition.

## OP-AP09 Muscle strength and power

### EFFECTS OF SHORT-TERM TRAINING ON CORTICOSPINAL EXCITABILITY AND CORTICAL INHIBITION DURING DUAL-TASK

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#### INTRODUCTION:

We have previously shown that long-term exercise reduces the degree of corticospinal excitement and results in plastic changes at the upper spinal level, including primary motor cortex (M1), during dual-task performance (ECSS, 2017; ECSS, 2019). It has been reported that short-term single task training also results in plastic changes in the local network surrounding M1 pyramidal cells (1). Furthermore, com-

bined transcranial magnetic stimulation (TMS) and electrical stimulation administered continuously over several days has been shown to expand the M1 region that controls that muscle (2). However, it remains unclear whether short-term dual-task training changes the process by which voluntary movements appear during dual-task performance. Therefore, this study aimed to investigate the effects of short-term dual-task training on corticospinal excitability and cortical inhibition in healthy adults, based on motor evoked potential (MEP), and cortical silent period (CSP) duration evoked by TMS.

**METHODS:**

The participants were 7 healthy adults (3 females and 4 males, 20.4±1.5 years of age) free of neurological disease who came to the laboratory 5 times over 2 weeks with an interval of 1 or 2 days between experiments. The participants performed tasks under the following 4 conditions at each visit: 1) Rest: resting; 2) Calc: calculating; 3) ST: retention of power gripping force with 10 or 30% MVC for 15sec; and 4) DT: simultaneously conducting 2) and 3) as a dual-task. In each task, TMS was applied to the left M1, and the MEP and CSP were recorded from the first dorsal interosseous, the flexor carpi radialis and the extensor carpi radialis of the right hand. The background EMG area (bEMG) in 100 ms before TMS was calculated.

**RESULTS:**

The main results of the experiment are as follows:

- 1) The bEMG area (%MVC) was not affected by short-term training under ST or DT conditions.
- 2) Short-term training increased MEP amplitude, especially under DT conditions.
- 3) Short-term training reduced the CSP duration (disinhibition), and the change was larger under DT conditions than under ST conditions.
- 4) MEP amplitude increased in the latter half of the training, but CSP duration began decreasing in the first half of the training.

**CONCLUSION:**

Short-term training increased corticospinal excitability and elicited a disinhibition phenomenon of cortical inhibition, especially under DT conditions. The disinhibition phenomenon was observed from the first half of training. These findings suggest that short-term training weakens (disinhibits) cortical inhibition to overcome motor-output interference, that is, a reduction in corticospinal excitability during the dual-task performance. Hence, short-term training may affect the balance between corticospinal excitability and cortical inhibition.

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**EFFECTS OF ALTERNATING UNILATERAL VERSUS BILATERAL STRENGTH TRAINING ON SPRINT AND ENDURANCE CYCLING PERFORMANCE IN TRAINED ENDURANCE ATHLETES: A THREE-ARMED RANDOMIZED CONTROLLED PILOT TRIAL**

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**INTRODUCTION:**

Adequate strength performance and training concepts are considered crucial issues within endurance sports. Thereby, strength training exercises reflecting similar mechanical specificity to the sports-specific movements have been reported to elicit higher sports performance gains. For example, a superior transfer effect to improve unilateral jump performance was found for unilateral strength and plyometric compared to bilateral training [1]. However, there is a lack of research regarding the potential for modifying exercise modality in strength training to improve endurance performance. Thus, we comparatively investigated the effects of strength training exercises with alternating unilateral execution and their transfer effects to sprint and endurance cycling performance.

**METHODS:**

20 trained endurance athletes were either assigned (strata: age, sex, VO<sub>2</sub>max and training volume) to an alternating unilateral [UL;n=7, VO<sub>2</sub>max=55ml/kg] or simultaneous bilateral [BL;n=7, VO<sub>2</sub>max =58ml/kg] training group, which completed 10 weeks of volume-load matched heavy strength training (leg press, -extension and -curls; 4 x 4-10RM) in addition to usual endurance training. A third group [CON;n=6, VO<sub>2</sub>max=60ml/kg] simply continued their usual training program.

Before and after the intervention period, power output at lactate thresholds (WLT1 and WLT2), cycling economy (CE), peak and mean power output (PPO and MPO), time to PPO (TTP), and acceleration index (AI: PPO/TTP) during 15s-sprint test, as well as maximal aerobic power output (W<sub>max</sub>), maximal oxygen uptake (VO<sub>2</sub>max) and time to exhaustion (T<sub>lim</sub>) at 105% of WLT2 were determined. Furthermore, measurements of maximal uni- and bilateral leg strength were carried out during voluntary isometric contraction.

**RESULTS:**

Maximal strength indices notably increased in both the BL and UL training group (~31%, p<.05), but not in CON. T<sub>lim</sub> improved in both intervention groups (UL:67%, BL: 43%, p<.05), whilst no significant change was found for CON. Significant deteriorations in sprint abilities were detected for CON (PPO: -6%, TTP: 25% and AI: -15%, p<.05). PPO and MPO (5% and 3%, respectively, p<.05) in BL significantly improved after training period, while no significant changes occurred in UL [3% (p=.18) and 4% (p=.06) for PPO and MPO, respectively]. Meaningful but statistically insignificant improvements in favour of UL were observed for TTP and AI [-12% (Cohen's d: -0.5) and 20% (Cohen's d: -0.5), respectively].

**CONCLUSION:**

This pilot trial underpins benefits of maximal strength training independent of its training modality for time trial performance and underlines risks of decreases in muscular power by performing long-term submaximal endurance training only. The tendency towards favourable effects of the unilateral strength training compared to bilateral training mode to acceleration within sprint testing needs to be confirmed in future research in both endurance and sprint cyclists in larger samples and over longer time frames.

1. McCurdy et al. (2005)

**THE EFFECT OF INDIVIDUALIZED POWER-TRAINING BASED ON FORCE-VELOCITY PROFILING IN HIGHLY-TRAINED TEAM SPORT ATHLETES**

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**INTRODUCTION:**

Samozino et al. (1) recently developed a simple and practical method to profile individuals as either force or velocity dominated by testing jump performance with increasing loads and including their limb length, body weight and jump-depth. A few studies have since investigated the effect of training towards optimizing a theoretical "force-velocity (f-v) imbalance" with positive results, however, it is not well

known if this method is applicable to elite athletes. The aim of this study was to investigate the effect of training towards reducing f-v imbalances in high-level national team players.

#### METHODS:

40 team sport athletes (21±5yrs, 83±13kg) from ice-hockey, handball and soccer completed a 10-week training intervention with two sessions per week. Based on their f-v profile (high force, high velocity or balanced), athletes were randomized to either heavy strength training (HST), speed and power training (PT) or balanced training (BT) (one strength and one speed/power). The athletes performed 10 and 30m sprints, squat jump (SJ) and counter movement jump (CMJ), 1 repetition maximum (1RM) squat and Keiser leg-press before and after the intervention. M. vastus lateralis thickness and architecture were measured by ultrasonography, and body composition by Dual-energy X-ray absorptiometry.

#### RESULTS:

Changes toward the optimal FV-profile (reduction in either force or velocity deficit) were unrelated to changes in SJ performance ( $r: -0.33$ ,  $p > 0.05$ ), and 52% ( $r^2$ ) of the change in SJ performance were explained by changes in bodyweight and baseline jump height ( $p = 0.02$ ). No group differences were detected in training-induced changes of SJ height, but only PT ( $4.5 \pm 6.0\%$ ,  $p = 0.01$ ) and BT ( $5.7 \pm 6.4\%$ ,  $p < 0.01$ ) increased SJ height from baseline (HST:  $3.2 \pm 8.1\%$ ,  $p = 0.21$ ). The HST group increased bodyweight ( $1.12 \pm 1.59$  kg,  $p = 0.04$ ), whereas the PT group tended to decrease bodyweight ( $-0.91 \pm 1.93$  kg,  $p = 0.01$ ) and significantly reduced lean mass in the legs ( $-0.76 \pm 0.69$  kg,  $p = 0.04$ ). Only the HST and BT group increased muscle thickness ( $8.5 \pm 6.0\%$  and  $7.4 \pm 8.3\%$ , respectively) and leg-press maximal power ( $8.5 \pm 7.4\%$  and  $3.8 \pm 4.9\%$ , respectively, all  $p < 0.05$ ), with no significant changes in the PT group ( $1.5 \pm 5.6\%$ ,  $p = 0.34$ ). No significant changes were observed in muscle pennation angle and fascicle length. With no group differences, small or trivial increases ( $ES < 0.45$ ) were observed in CMJ, 1RM back squat and sprinting performance.

#### CONCLUSION:

Individualizing strength training programs based on FV-profiling in SJ did not seem to improve performance measures compared to a balanced approach. Overall, the balanced approach with one heavy-strength and one speed/power focused session per week (balance) seemed most beneficial for team sport athletes in season. Changes in jumping performance was highly influenced by changes in body mass, hence caution should be taken when evaluating the effectiveness of training interventions based on changes in jumping performance. Especially for high level athletes.

Samozino et al. 2014

### EFFECTS OF CLUSTER VS. TRADITIONAL SET CONFIGURATION ON THE RATE OF FORCE DEVELOPMENT AND MUSCLE ARCHITECTURE

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#### INTRODUCTION:

The inter-repetition rest strength training method (clusters strength training) induce similar increases in muscle strength and power as traditional strength training (Nicholson et al., 2016). Yet, the effect of cluster strength training on the rate of force development (RFD) and muscle architecture remains unexplored. The purpose of the study was to compare the effects of strength training with clusters set configuration or traditional set configuration on muscle strength, RFD and muscle architecture, in moderately-training participants.

#### METHODS:

Sixteen male participants were assigned into two groups: the Cluster group (CG, N=8) and the Traditional group (TG, N=8). Training was performed 2/week for 7 weeks using leg press and bench press. Both groups performed 4 sets of 6 repetitions of 1-RM. The CG group applied 20 seconds inter-repetition rest (Hardee et al., 2012), while the rest between sets was approximately 3 minutes for both groups. Measurements included 1-RM strength in leg press and bench press, isometric leg press RFD (LRFD) and peak force (LPF), isometric chest press RFD (CRFD) and peak force (CPF), as well as muscle architecture of vastus lateralis (VL), vastus intermedius (VI) and triceps brachii (TB) with ultrasonography. A 2-way ANOVA for repeated measures with Bonferroni post hoc was used for the determination of differences between measurements. Significance was accepted at  $p \leq 0.05$

#### RESULTS:

Overall, RFD remained unaltered for the upper and lower limbs, but CG induced greater percentage increases at 30, 50 and 80ms of the LRFD ( $P < 0.05$ ) and at 50 and 80ms of the CRFD ( $P < 0.05$ ), compared to TG. LPF increased for both groups ( $P < 0.05$ ) but CPF increased only after CG ( $P = 0.009$ ). 1-RM strength in leg press and bench press increased significantly for both groups ( $P < 0.05$ ), although, percentage increase in bench press was greater for CG compared to TG ( $P = 0.027$ ). VL and VI muscle thickness increased in both groups ( $P < 0.05$ ). The percentage increase of VL fascicle length was significantly greater for CG compared to TG ( $P = 0.009$ ). No significant changes were observed for TB muscle architecture after both training programs.

#### CONCLUSION:

The results of the present study suggest that 20 seconds rest between repetitions during strength training may effectively increase upper body 1-RM strength, leg press and chest press early RFD, as well as VL fascicle length. From a practical perspective, clusters sets configuration can be used effectively for increasing fast force production and simultaneous increase in muscle hypertrophy and strength.

### FROM ACUTE TO CHRONIC TRAINING ADAPTATIONS.

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#### INTRODUCTION:

Concurrent training (CT) consists of strength training (ST) and endurance training (ET). The training element done first affects performance in the second element and ultimately the magnitude of chronic adaptations to CT, particularly in muscle power quantified by vertical jump height. However, previous studies have only examined the acute and chronic adaptations to CT in isolation. Furthermore, when children perform CT, ET may actually potentiate muscle power. Therefore, the present study aimed to determine the chronic effects of exercise sequence and the acute effects of ST and ET components of CT on jump height. Furthermore, we aimed to quantify the associations between acute and chronic exercise effects.

#### METHODS:

Sixty-three male young soccer players (aged 13-18y) were pair-matched for vertical jump height and the pairs were randomly assigned to either group SE that performed 15 minutes of ST first followed by 15 minutes of ET or group ES that performed ET first followed by ST. ST consisted mainly of plyometric exercises, ET of small sided-games. Vertical jump height was assessed prior to and following eleven weeks (2x/week) of CT with a countermovement jump (CMJ). Additionally, participants performed one CMJ before and after individual components of ST and ET every other week. We tested between group differences in jump height with t-tests and quantified the associations between acute and chronic effects with Pearson correlation coefficients.

**RESULTS:**

After 11 weeks, young soccer players increased CMJ from  $28.8 \pm 5.0$  to  $30.3 \pm 5.7$  cm ( $p < 0.001$ , [Cohen's]  $d = 0.23$ ), irrespective of the exercise sequence (SE:  $+1.2 \pm 3.1$  cm, ES:  $+1.7 \pm 3.0$ ,  $p = 0.59$ ,  $d = 0.16$ ). ET acutely increased CMJ ( $+0.5 \pm 2.6$  cm,  $p = 0.001$ ,  $d = 0.10$ ), irrespective of the exercise sequence ( $p = 0.30$ ,  $d = 0.11$ ). Pearson correlation coefficients between acute CMJ (post ET – pre ET) and chronic CMJ ( $w_{12} - w_0$ ) in the ES group ranged from  $r = -0.2$  to  $0.1$ . Compared with baseline, ES group jumped higher than SE group at the onset of ST (ES:  $+5\%$ , SE:  $+1\%$ ,  $p = 0.02$ ,  $d = 0.40$ ). CMJ at onset of ST was correlated with chronic CMJ ( $r = 0.4$ – $0.6$ ).

**CONCLUSION:**

The results of the present study suggest that 15 minutes of ET acutely increased CMJ. However, the acute effect of ET on CMJ was only trivially to weakly associated with the chronic adaptation. The acute effect of ET on CMJ was in line with the ES group jumping higher at onset of ST. Young soccer players who jumped higher at onset of ST, and suggestively during ST, showed the largest chronic increase in CMJ. Despite this, exercise sequence of ET and ST had a trivial effect on the development of muscle power.

In conclusion, the sequence in which young athletes perform ET and ST has a negligible effect on the chronic development of muscle power. We did not find evidence for an acute effect of ET explaining the chronic adaptation in jump height. Our findings suggest that jump height prior (and possibly during) ST is indicative of chronic adaptations in muscle power.

**PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION INTERSET 10-6-10 PROTOCOL INFLUENCE ON MUSCULAR FORCE QUALITIES ADAPTATION IN BENCH PRESS**

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**INTRODUCTION:**

Strength training and stretching are part of many sports, rehabilitation plans and performance improvement [1]. The aim of this study was to analyze the influence of proprioceptive neuromuscular facilitation (PNF) interset 10-6-10 stretching protocol on the muscular force qualities in Bench press (BP).

**METHODS:**

A total of 18 subjects participated (age =  $20.7 \pm 2.1$  years; height =  $167.5 \pm 9.05$  cm), were randomly distributed in two groups: control group (CG) ( $n = 8$ ) and experimental group (EG) ( $n = 10$ ). Both groups performed a training intervention during 6 weeks, 2 sessions per week, 4 sets of 2 repetitions with submaximal loads every session and 5 minutes recovery between sets. The EG also completed a PNF protocol before each set, consisting in 10 seconds of stretching, 6 seconds of contraction and another 10 seconds of stretching. To analyze the executions of the BP a whole MR protocol was performed by every subject. During the sets, the kinematics of the bar was recorded using the Xsens system and its mechanical power and mechanical work were calculated by their respective expressions:  $P = F \cdot v$  (W),  $W = \int_{t_1}^{t_2} P dt$  (J), in addition, to detect the potential of muscle activation, superficial electromyography electrodes was used. Data processing was performed using Matlab software. A Kolmogorov Smirnov test for normality was performed. As variables turned out to have a normal distribution T-Test was applied

**RESULTS:**

The results showed no significant different improvements between CG and EG in maximum strength ( $9.1 \pm 5.7\%$  and  $9.5 \pm 7.7\%$  improvement in EG and CG respectively). Beside, EG did not adapt the same magnitude as CG in muscular strength qualities during eccentric phase: mechanical work ( $56 \pm 36\%$  of EG improvement vs  $102 \pm 70\%$  of improvement in CG) and maximum mechanical power ( $60 \pm 43\%$  improvement in EG vs  $153 \pm 146\%$  improvement in CG). During concentric phase, neither have both groups adapted in the same way: mechanical work ( $31 \pm 18\%$  of EG improvement vs  $67 \pm 35$  in CG) and maximum mechanical power ( $29 \pm 31\%$  of EG improvement vs  $97 \pm 99\%$  in CG). No statistically significant differences were found between both groups. Only CG showed a significant decrease in electromyographic activity of deltoid and pectoral muscles during low loads sets ( $p < 0.05$ ), and an increase in the intensity in biceps and triceps ( $p < 0.05$ ), during high loads sets.

**CONCLUSION:****CONCLUSION:**

In conclusion, to perform a PNF inter-set 10-6-10 protocol before every set in a strength training program has no additional benefit on muscular performance. It seems that PNF protocol interferes with the adaptation of muscle strength qualities, especially in high loads, reducing the margin of improvement.

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**RELATIONSHIP OF VERTICAL JUMPING PERFORMANCE AND NON-MOTORIZED TREADMILL SPRINTING POWER IN YOUNG MEN AND WOMEN**

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**INTRODUCTION:**

In recent years, there has been an increasing interest in the assessment of sprinting performance using non-motorized treadmills (NMT). Despite increased use of NMT the meaning and influencing factors of NMT parameters are still rather unclear [1]. The aim of this study is therefore to investigate the relationship of NMT sprinting parameters and vertical jumping performance to better understand the meaning of NMT parameters and detect potential differences between men and women.

**METHODS:**

Twentyfive healthy sports students ( $f=15$ ,  $m=10$ ; age =  $25.1\pm 4.3$  yrs) with similar physical condition performed a 10-s two foot ankle hop (TFAH) and three counter movement jumps (CMJ) interspersed by 1 min passive rest on a contact mat (Fitro Fitro Jumper, Fitronic s.r.o.,SK). After a passive rest of 15 min, subjects performed 3x6 s maximum effort sprints interspersed by 4 min passive rest on a NMT (Woodway Force 3.0, Woodway Inc., USA). Analyzed Parameters were: highest power in NMT sprinting (PPO), average power in NMT sprinting (MPO), CMJ jumping height (JH) and TFAH jumping height divided by contact time (SI). Men and Women were analyzed separately and for each group the correlation coefficient according to Pearson was calculated. The Fisher z-transformation was used to investigate differences between men and women. Significance levels were set at the 5% level.

**RESULTS:**

For men there was a significant relationship between PPO and SI, and PPO and JH ( $p<.05$ ,  $r=.645$ ;  $p<.05$ ,  $r=.719$ , for SI and JH, respectively). No significant relationship was found between MPO and SI, and MPO and CMJ. For women there was a significant relationship between PPO and SI ( $p<.01$ ,  $r=.661$ ) as well as MPO and SI ( $p<.01$ ,  $r=.695$ ) and no significant relationship was found between PPO and JH and MPO and JH. The Fisher z-transformation identified no significant differences between the correlation coefficients of men and women.

**CONCLUSION:**

The novel finding of this work is that jumping performance is a useful factor to predict sprinting performance on the NMT. Prior studies have noted the importance of jumping performance (CMJ, TFAH) to predict overground sprinting performance [2,3]. Particularly, reactive forces assessed by TFAH performance could be a predictor for PPO of men and women. For men also explosive power assessed by CMJ performance could be a key factor to predict PPO. For women TFAH performance predicts MPO. However, the correlation coefficients did not differ significantly between men and women.

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**QUADRICEPS STRENGTH ASYMMETRY IS NOT SYSTEMATICALLY RELATED TO ASYMMETRY IN NEUROMUSCULAR FUNCTION**

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**INTRODUCTION:**

Substantial quadriceps strength asymmetries have been found in a variety of populations and are typically measured by quantifying the inter-limb difference in maximum strength (the maximum force a muscle can produce). These asymmetries can be above what some have suggested as a potential injury risk, and have been linked to performance deficits [1]. However, little is known about the extent of asymmetry in explosive strength (the muscle's capacity to rapidly exert force), which may arguably be more functionally relevant to human movement. Furthermore, the neuromuscular determinants of strength asymmetries are unclear. Therefore, the purpose of this study was to determine the magnitude and variability of quadriceps strength asymmetry and its underpinning neuromuscular determinants.

**METHODS:**

Physically active males ( $n=21$ ) performed voluntary maximal and explosive isometric contractions of the knee extensors in an isokinetic dynamometer, to measure maximum voluntary torque (MVT; measures maximum strength) and peak rate of torque development (RTD; measures explosive strength). Determinants of strength were also assessed. Electrically evoked involuntary (300 Hz octet) contractions assessed intrinsic contractile properties. Neural activation at MVT was assessed by the interpolated twitch technique (Voluntary Activation), and by EMG amplitude normalised to maximal M-wave. Explosive neural activation was measured by normalised EMG over the first 100 ms of explosive contractions. Static ultrasound images of the vastus lateralis muscle were captured to measure muscle thickness, pennation angle, and fascicle length. Bilateral strength asymmetry (BSA, [2]) was calculated for each variable.

**RESULTS:**

There was no difference in the magnitude of strength asymmetry (BSA MVT 10%, BSA RTD 13%;  $p=0.173$ ) despite greater variability in BSA RTD (BSA MVT range=16%, SD=5%; BSA RTD range=35%, SD=9%). Although asymmetry was not always in the same direction (i.e. the maximally strong limb was not necessarily the more explosive limb in 8 out of 21 participants) a moderate correlation was apparent between BSA MVT and RTD ( $r=0.56$ ,  $p=0.008$ ). No correlations were apparent between BSA MVT or RTD and BSA of any of the predictor variables for either of these measures. Neither were asymmetries in any of the neuromuscular determinants in the same direction as the asymmetries in either MVT or RTD.

**CONCLUSION:**

No difference in the size of inter-limb asymmetries between maximal and explosive strength was apparent, although explosive strength BSA was more variable and not always in the same direction as maximum strength BSA. Practitioners should therefore consider monitoring asymmetry in both aspects of strength. Additionally, neither maximum nor explosive strength asymmetry was explained by a systematic combination of asymmetries in the neuromuscular factors which are thought to determine strength.

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**VELOCITY-BASED TRAINING: IMPLICATIONS FOR PERFORMANCE OPTIMIZATION AND TRAINING PLANNING - A SYSTEMATIC REVIEW**

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**INTRODUCTION:**

Velocity-Based Resistance Training (VBRT) is gaining growing popularity, and is based on on-line feedback of the movement velocity of a given exercise, which is performed with the intent to move the load as fast as possible. The purpose of this systematic literature review was to investigate the current knowledge regarding the effect of VBRT on neuromuscular performance (maximal strength and power), and to evaluate the approach of monitoring and managing fatigue and adjusting training volume via on-line feedback of movement velocity and velocity loss during exercise.

**METHODS:**

A total of 19 VBRT studies (486 participants) were identified through systematic search in Pubmed, Scopus, Ebsco (Sportdiscus) and Embase (Ovid).

**RESULTS:**

VBRT appeared to have clear performance enhancing effects on maximal muscle strength and power with training intensities ranging from 45-80% 1RM and only few repetitions performed. Further, training at maximal intended velocity led to superior neuromuscular adaptations versus slow training at 50% of maximal velocity ( $\Delta 1RM \sim 18\%$  vs.  $10\%$ ). Velocity loss demonstrated strong linear relationships to mechanical ( $r=0.74-0.97, p<0.05$ ) and metabolic ( $r=0.95-0.97, p<0.05$ ) markers of fatigue, altogether suggesting that training volume could be adjusted via online feed-back on velocity loss to avoid build-up of excessive fatigue. Further, strong linear relationships were found between the individual percentage of velocity loss and percentage of repetitions performed relative to the maximum possible number that could be completed ( $r^2 = 0.88-0.97$ ), which could be used to accurately quantify the individual "level of effort". Finally, the individual "level of effort" could be redefined as an "Effort Index" based on the relationship between velocity of the fastest repetition and percentage velocity loss, in turn providing an opportunity to objectively monitor training stress in individual athletes.

**CONCLUSION:**

VBRT was found to be effective of inducing specific neuromuscular adaptations, where a low percentage velocity loss minimizing build-up of fatigue led to comparable or more pronounced gains in strength ( $\Delta 1RM$  2-18 % vs. 4-13%) and vertical jump height ( $\Delta CMJ$  5-9% vs. -3-4%) compared to training with a high velocity loss and more pronounced fatigue development. Despite a low overall training volume, velocity based resistance training (VBRT) involving high intended movement velocity and low velocity loss results in comparable or superior adaptations in maximal muscle strength and power compared to conventional resistance training.

**THE RELIABILITY OF A SIMPLE TWO POINT METHOD FOR ASSESSING VERTICAL FORCE-VELOCITY PROFILES: HOW DOES JUMP EXPERIENCE MATTER?**

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**INTRODUCTION:**

Force-velocity (Fv-) relationships of ballistic push-offs are typically assessed via linear regression of repeated measurements with at least five additional loads [1, 2]. For performance assessment, a reduced amount of repeated measures is advantageous (i.e. test efficiency). Although a 2-point method has been shown to have a high correlation with multiple point methods, individual differences of up to 10% were reported too [3, 4]. This insufficient precision for performance diagnostics could be attributed to investigating athletes with average jump experience. Furthermore, a flaw of existing evaluations on the 2-point method is that data from a multiple point method were used for deriving the 2-point Fv-relationship (i.e. no independent data collection). Therefore, the aim of the present study was to test the reliability of the "independent" two-point method on populations with different jump experiences.

**METHODS:**

15 elite ski jumpers (SJ; highly experienced in jumping) and 15 sports students (SS; normal jump experienced) underwent a repeated measures design including two sessions. Participants performed squat jumps at load conditions of 0% and +80% of body mass in both sessions. According to a standard method, 2-point Fv-relationships were calculated [2, represented by  $F_0$ ,  $v_0$ ,  $P_{max}$  and  $S_{fv}$ ]. Test-retest reliability for each group was evaluated by the coefficient of variation (CV [95% CI]), the relative change in the mean (CIM), and the intra-class correlation coefficient (ICC, model 3.1) [5].

**RESULTS:**

CV values for SJ were below 5% whereas the less experienced group of SS showed substantially higher values for  $v_0$  (8.4 [6.0, 13.0]) and  $S_{fv}$  (13.3 [9.7, 21.0]). CIM results were in the order of <2% for all parameters in both groups. CIM 95% CI were below 5% except for SJ  $v_0$  (1.8 [-4.9, 8.1]) and  $S_{fv}$  (-2 [-10.3, 10.6]). The ICCs were excellent for  $F_0$ ,  $v_0$  and  $P_{max}$  with 95% CI between .89 and .99 for the SJ group. However, the ICC for  $S_{fv}$  was not acceptable (<.74) with 95% CI between .53 and .93. The SS group showed good ICC values for  $F_0$  (.82 [.55, .94]) and  $P_{max}$  (.81 [.52, 0.93]), but not acceptable for  $v_0$  (.52 [.03, .81]) and  $S_{fv}$  (.59 [.13, .84]).

**CONCLUSION:**

In the group of experienced athletes, excellent reliability was determined for all parameters whereas the less experienced group obtained substantial lower reliability. Consequently, the independent 2point-method can be considered reliable for a highly experienced population. The 2point-method was previously generally recommended for creating Fv-relationships [4]. However, using average experienced participants like sport students (frequently used for intervention studies), multiple-point methods need to be performed.

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**EFFECT OF DIFFERENT TRAINING LOADS AND VARIABLES USED ON PERFORMANCE ANALYSIS IN STRENGTH TRAINING**

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**INTRODUCTION:**

Measuring movement velocity during resistance training (RT) has proved to be a valid method of monitoring actual relative intensity (González-Badillo & Sánchez-Medina, 2010) and fatigue levels of a training session (Pareja-Blanco et al., 2017) but, there is a lack of information regarding the use of the applied force to assess daily performance in a dynamic exercise. Therefore, the aim of this study was to compare the use of these two variables to evaluate adaptations in two different RT programs.

**METHODS:**

Forty-five physically active subjects ( $25,0 \pm 7,3$  years;), who performed an incremental submaximal 1RM test ( $72,1 \pm 25,0$  kg) in the back squat exercise, were divided into two groups to train for 11 sessions twice a week: 80% 1RM Group (G80) and 40% 1RM Group (G40). Performance was assessed by lifting a fixed absolute load (60% 1 RM) on a force platform connected to a linear velocity transducer in order to acquire three different variables: Mean Propulsive Velocity (MPV), Mean Propulsive Force (MPF) and Mean Propulsive Power (MPP). A

general lineal model of repeated measures was used to detect changes between groups. Significant main effects were followed-up by Bonferroni post-hoc procedures. Significance was set at  $p < 0.05$ .

**RESULTS:**

Performance improvements were statistically significant in the following cases depending on the variable of study: MPV, G40 sessions 8th ( $p = 0.004$ ), 9th ( $p = 0.030$ ) and 10th ( $p = 0.000$ ); MPF, G40 session 10th ( $p = 0.005$ ) and G80 session 11th ( $p = 0.022$ ); MPP, G40 sessions 8th – 11th ( $p$ -value ranges from 0,016 to 0,000) and G80 session 11th ( $p = 0,025$ ).

**CONCLUSION:**

Time course adaptations to RT depend on the chosen variable to monitor daily performance. The use of a force platform might provide slightly different result to what can be obtain from a linear velocity transducer. Regardless of the variable used, a low intensity RT program produced larger improvements against medium loads than a high intensity RT program.

**A NON-LINEAR ANALYSIS OF RUNNING IN THE HEAVY AND SEVERE EXERCISE DOMAINS**

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**INTRODUCTION:**

Healthy physiological systems produce outputs which demonstrate intrinsic variability and complexity, but in diseased and aged populations complexity is decreased. Complexity of torque output has been shown to decrease above the critical torque (Pethick et al., 2006). Critical velocity (CV) is physiologically analogous to critical torque and demarks the heavy and severe exercise intensity domains (Jones et al., 2008). Research examining changes to complexity during whole-body exercise is limited, and no investigations has explored complexity around CV. The aim of this study was to analyse differences in the variability and regularity of lower limb kinematics in heavy and severe intensity domains during running.

**METHODS:**

Ten healthy participants performed a running task at 95%, 100%, 105% and 115% of CV (CV95, CV100, CV105, CV115) on a treadmill for 20 min or to task failure (Tlim), whichever occurred sooner. Joint kinematics of the hip, knee, and ankle were sampled throughout using 3D motion analysis. Regularity of kinematics in the first and last 30 sec were quantified using sample entropy (SampEn) and detrended fluctuation analysis- $\alpha$  scaling exponent (DFA- $\alpha$ ). Variability was determined using standard deviation (SD). Two-way repeated measures ANOVA was used to determine differences in regularity and variability between intensities and the first and last 30 sec.

**RESULTS:**

The mean CV was  $4.21 \pm 0.43$  m·s<sup>-1</sup>. Tlim was lower in CV115 ( $3.27 \pm 0.67$  min) than CV105 ( $8.03 \pm 2.36$  min), CV100 ( $16.68 \pm 4.41$ ), and CV95 ( $20.00 \pm 0.00$  min) [ $P < 0.05$ ]. There were no interaction effects between running velocity and time. SampEn decreased during all trials in knee flexion/extension ( $P < 0.05$ ) and increased in hip internal/external rotation ( $P = 0.001$ ), whilst DFA- $\alpha$  increased in knee internal/external rotation ( $P < 0.05$ ). SD increased for ankle plantar/dorsiflexion ( $P < 0.05$ ) and inversion/eversion ( $P < 0.01$ ), knee internal/external rotation ( $P = 0.001$ ), and hip flexion/extension ( $P = 0.001$ ) and abduction/adduction ( $P = 0.002$ ). Hip flexion/extension SampEn values were greater in velocities at or above CV compared to velocities below CV ( $P < 0.05$ ). DFA- $\alpha$  was lower at higher velocities compared to velocities below CV in ankle plantar/dorsiflexion, hip flexion/extension, hip adduction/abduction, hip internal/external rotation ( $P < 0.05$ ). In hip flexion/extension SD was highest in CV115 compared to lower velocities ( $P < 0.05$ ).

**CONCLUSION:**

Changes to kinematic regularity and variability over time are consistent between heavy and severe intensity domains. The findings suggest the CV does not demark a boundary above which there are changes to complexity or variability in kinematics during treadmill running. Changes during running on a motorised treadmill at a constant velocity may be limited to fluctuations in variability in lieu of changes to regularity.

**CHRONIC STRENGTH TRAINING DOES NOT ALTER MOTOR UNIT BEHAVIOUR DURING SUBMAXIMAL ISOMETRIC CONTRACTIONS**

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**INTRODUCTION:**

The rapid increase in maximum force occurring in the first weeks of strength training is mediated by changes in the neural (1) and peripheral (2) properties of motor units (MU), which precede muscle growth (3). However, the effects of long-term exposure to strength training on motor unit behaviour have yet to be elucidated. Motor unit behaviour during isometric voluntary contractions was compared between chronically strength-trained athletes and untrained individuals in this study.

**METHODS:**

Sixteen strength-trained (ST) athletes (age:  $23 \pm 4$  yr; body mass:  $88 \pm 13$  kg) and fourteen untrained (UT) individuals (age:  $20 \pm 2$  yr; body mass:  $75 \pm 11$  kg) performed maximal voluntary isometric force contractions (MVIF) and linearly increasing isometric ramps with a steady state of 10 s at the target forces (15, 35, 50, 70% MVIF, at 10% MVIF·s<sup>-1</sup>), with elbow flexors. Myoelectrical activity from the biceps brachialis muscle was recorded with two high-density surface EMG grids of electrodes each. EMG signals were decomposed into individual MU discharge timings (4) and motor unit characteristics (recruitment threshold forces and discharge rate during the different phases of the submaximal contractions) were extracted and compared between-groups (one-way ANOVAs).

**RESULTS:**

ST athletes showed significantly higher MVIF compared to the UT individuals ( $457.7 \pm 52.7$  vs  $276.8 \pm 54.9$  N,  $P < 0.001$ , +60.4%). Absolute MU recruitment threshold forces was higher in ST compared to UT individuals ( $59.6 \pm 10.1$  vs  $36.1 \pm 8.9$  N,  $P < 0.001$ ). Conversely, MU recruitment threshold forces normalized with respect to MVIF ( $32.5 \pm 3.2$  vs  $30.4 \pm 4.9$  % MVIF,  $P = 0.215$ ), average MU discharge rates ( $20.3 \pm 3.3$  vs  $19.9 \pm 4.2$  pps,  $P = 0.815$ ) and discharge rate at the steady state ( $20.7 \pm 3.3$  vs  $20.3 \pm 4.2$  pps,  $P = 0.787$ ) of the isometric ramp contractions did not differ between the two groups. This behaviour was consistent with all the four target forces (no significant condition x group interaction in all cases,  $P > 0.05$ ).

**CONCLUSION:**



Despite the substantially higher maximal strength resulting from the long-term exposure to strength training, motor unit recruitment strategies and discharge characteristics of ST athletes were similar to those observed in untrained individuals during submaximal force modulating tasks. Muscular rather than neural adaptations likely explain the differences in the absolute forces generated during submaximal isometric voluntary contractions, when the nervous system does not require maximal speed and force production (5).

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**EFFECT OF A POWER-ORIENTED RESISTANCE TRAINING PROGRAM AT MODERATE ALTITUDE ON CURRENT AND OPTIMAL FORCE-VELOCITY RELATIONSHIPS IN ELITE JUDOKAS**

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INTRODUCTION:

Strength and power levels are widely considered a potential predictor of judo performance (1). Improvements in explosive actions at moderate altitude are expected due to the reduction in aerodynamic resistance and the increase in anaerobic metabolism, fast fiber recruitment and spinal excitability described at higher altitudes (2-4). Although emerging evidence supports the use of moderate altitude training to improve leg extension power capacity (5,6), the potential influence of environmental hypoxia on acute and chronic responses to strength training remains largely unexplored. Therefore, the aim of this study was to analyze the effect of a power-oriented resistance training (RT) program at moderate altitude on lower limb force-velocity (F-V) profile of judokas and its relationship with their optimal profile.

METHODS:

22 male elite judokas performed a 3-week power-oriented RT program (3 sessions-week<sup>-1</sup>) either under normoxia (NT, n=10, sea level) or moderate altitude (HT, n=12, 2320 m asl). Before (N1) and after the RT program (N2) and 1 week later (N3) countermovement jump height was recorded during a five-load submaximal test to determine maximum theoretical force (F0), velocity (V0) and power (P0) in normoxic conditions by using the Samozino's method. The optimal F-V profile and imbalance were also determined (7).

RESULTS:

A main effect of the RT program was observed in F0 (p=0.005, edta square=0.251). With respect to pretest, HT displayed the best increase in F0 in N2, while in NT reached it in N3 (+11.77%, p=0.003; +7.61%, p=0.014 for HT and NT, respectively). In addition, a small to moderate reduction in the difference between the current and the optimal F-V profile from N1 to N2 in HT (-11.96%, ES:0.66) and from N1 to N3 in NT (-7.88%, ES:0.85) was observed (p<0.10), although there were no differences between groups. Optimal and current P0 values did not change at any condition but displayed important imbalances due to lower current values in F0 and higher in V0 compared to the optimal ones (p<0.001, edta square>0.844).

CONCLUSION:

Results confirm that muscular power training is viable at moderate altitude without negatively impacting results and with increases in F0. There was a clear tendency to a faster and higher reduction of the F-V imbalance under hypoxia vs normoxia, although findings did not reach statistical significance seemingly due to individual variability and the small sample size. Moderate altitude training seems to be beneficial for leg extension improvements as previously demonstrated (5,6), mostly by accelerating the peak performance.

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**MONITORING STRENGTH TRAINING IN ELITE FOOTBALL: RELIABILITY OF FLYWHEEL POWER MEASURES AND DIFFERENCES BETWEEN AGE GROUPS**

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INTRODUCTION:

Systematic monitoring of players individual responses to training is now an integrated part of daily practice of elite level football clubs. Strength training programmes are often proposed in training frameworks in order to improve players physical capabilities and injury prevention. Advances in technology allow for the measurement of power values while using flywheel devices, highlighting their potential to elicit an eccentric overload. To date the reliability of power values recorded utilizing flywheel technology has not been reported. Limited information is available regarding the load expressed using flywheel devices by elite youth and adult soccer players. The aims of this study are to verify inter-session reliability of power values and leg asymmetries recorded during 3 single leg exercises performed using flywheel devices. Differences in power values recorded across three different age groups were also investigated.

METHODS:

47 elite level soccer players from the U17 (n=15), U19 (n=15) and first team (FT; n=17) were monitored in this study. Reliability was assessed using the measures from 2 gym-based sessions separated by 15 days of training (n=29). Players performed 1 series of 8 repetitions of leg press (LP), side squat (SS) and hamstring kicks (HK). The power values were recorded using an optical power encoder (SmartCoach,

Sweden). For the analysis, peak power output (PPO) and leg asymmetry (ASYM - %) were assessed. The reliability is expressed as a typical error as a coefficient of variation (%) and interclass correlation were calculated; effect sizes and magnitude-based inference were calculated for the differences between groups.

#### RESULTS:

The reliability of the 3 exercises was 9.7% for LP, 10.5% for SS and 11.2% for HK. Differences between concentric and eccentric power values reliability were only found in LP (8.7% CON – 10.7% ECC;  $p=0.002$ ). ASYM was 12.1%, 18.5% and 13.4% for LP, SS and HK respectively. U17 have significantly lower PPO values than FT across all three exercises (CON: likely, ECC: very likely). In LP, U19 differ from FT only in ECC PPO (-12%;  $d=-0.54$ ; likely). There were no significant differences in SS between U19 and FT (unclear), with U19 significantly greater than U17 in CON PPO (-10.7;  $d=-0.57$ ; likely). PPO values of the 3 teams were significantly different from the other in HK (U17: 398 W; U19: 457 W; FT: 560 W).

#### CONCLUSION:

Monitoring individual players physical development can be facilitated by assessing changes recorded in levels of PPO. However, caution should be used when appraising the PPO data recorded on flywheel devices due to the 10.5% difference between sessions. The 14.5% variability between sessions indicates flywheel devices should not be considered as a functional evaluation of ASYM. In agreement with previous studies, the ECC peak of the hamstring muscles appears to be the greatest discriminating factor between age groups. A greater understanding of power data can assist practitioners to develop the players physical qualities.

## OP-AP10 Biological age and master athletes

### POSITIVE EFFECTS OF TWO ISO-POTENTIAL STRENGTH TRAINING PROGRAMS, DIFFERING IN SPEED OF EXECUTION AND LOAD INTENSITY, ON THE DYNAMIC BALANCE AND CHANGE OF DIRECTION SKILL OF HEALTHY OLDER ADULTS.

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#### INTRODUCTION:

The ability to generate strength and power declines earlier and at a higher rate than the loss of muscle mass (1). Power production is the result of the product of force and velocity, and the influence of the velocity and force at which the maximum power is reached on functional performance has been recently analysed (2).

Similar power outcomes can be obtained at different velocities as the inverse force-velocity relationship implicitly implies a parabolic relationship between power and velocity. Therefore, two iso-power points can be established at the two sides of the parabolic function differing in the speed of execution and force applied when performing at the maximum intentional velocity (3).

The main objective of this study was to explore the effect of two iso-potential training programs, performed at different loads and different velocities on the functional performance of healthy older adults.

#### METHODS:

We carried out a randomized control trial allocating thirty-seven healthy adults older than sixty years in two training groups, high velocity (HV) and low velocity (LV), and one control group (CON). Training interventions consisted of 2 sessions/week throughout 5 weeks of power training at two training iso-power models, where load intensity and speed of execution were differentiated when performing at the maximum intended velocity. The total volume and recovery were equated between experimental groups. Before and after the intervention participants performed a progressive load test to obtain the load-power ratio (% 1RM-W, Egm-Germany) on three strength exercise: lat pull (LP), chest press (CP) and leg press (LgP); and the timed up and go test (TUG).

#### RESULTS:

Both training groups improved TUG performance at a similar level (HV,  $p<0.001$ , Hedge's  $g=-0.417$ ; LV,  $p=0.003$ , Hedge's  $g=-0.530$ ), whereas CON was unchanged ( $p=0.850$ , Hedge's  $g=0.050$ ).

#### CONCLUSION:

Power training caused a significant improvement in the TUG test, where performance on that task depends on a composite of the ability to stand up from a chair, gait velocity (dynamic balance), change of direction and sit down on a chair, being these skills representative features of functionality of older people. Furthermore, similar improvements were obtained for both training protocols which employed similar power but differed in load and velocity prescribed.

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### PHYSICAL FITNESS EFFECTS OF 16 WEEKS OF RECREATIONAL TEAM HANDBALL TRAINING FOR OVER 60-YEAR-OLD MEN

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1:CIDESD ISMAI, 2:SHSC-SDU, 3:SSHS-UE, 4:SUS, 5:ST-FIGC, 6:UTV, 7:CIAFEL, FADEUP, 8:IPDJ

#### INTRODUCTION:

Health services face major challenges when tackling chronic diseases related to an unhealthy lifestyle, and promoting healthy ageing is a major world concern (1). Physical activity declines with age, however, physically active men have a 20–30% reduced risk of premature death and 50% less prevalence of chronic diseases (2). Given the importance of physical activity, finding new and motivating opportunities for older adults to exercise should be a priority. Recreational team-handball (RTH)-based exercise programmes have shown to be effective in improving health and physical fitness in formerly trained adult men and in untrained young women and men (3-5). However, the effects of this exercise programme on physical fitness have not yet been studied for over 60-year-old men with no experience in the sport.

#### METHODS:

The participants ( $n=55$ ) were randomly allocated to control or intervention (1, 2 or 3 one-hour weekly sessions) groups. The RTH intervention groups (RTH1, RTH2, RTH3) performed a 16-week exercise programme (60-min sessions comprising a 15-min warm-up and 45-min of 5v5, 6v6 and 7v7 games, in a 40x20m court). Participants' physical fitness, namely, upper and lower body strength, upper and lower body flexibility, agility and coordination, postural balance and aerobic performance (Yo-Yo intermittent endurance test-level 1, YYIE1) were

evaluated at baseline and at 16 weeks post-intervention. Participants' age, height, body mass and fat mass were  $67.7 \pm 3.9$  years,  $168.7 \pm 6.2$  cm,  $78.7 \pm 10.5$  kg and  $27.6 \pm 5.0\%$ , respectively.

**RESULTS:**

After 16 weeks, RTH groups improved upper and lower body strength, agility and coordination, ( $p < 0.00$ ) and YYIE1 performance ( $p < 0.001$ ). Only RTH2 improved upper body flexibility ( $p = 0.02$ ) and balance ( $p = 0.05$ ). Significant differences were found between RTH1, 2 and 3 and the control group in upper ( $p < 0.003$ ) and lower body strength ( $p < 0.01$ ), agility and coordination ( $p < 0.01$ ) and in YYIE1 performance ( $p < 0.05$ ). The control group showed no significant alterations in the evaluated variables.

**CONCLUSION:**

Short-term RTH was effective in improving physical fitness of over 60-year-old men with no experience in the sport, regardless the weekly frequency (1, 2 or 3 sessions/week). Nevertheless, the groups that performed 2 and 3 weekly training sessions showed greater physical fitness improvements.

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**INVESTIGATING THE MATCH WORKLOAD IN OLDER ADULT BASKETBALL PLAYERS: PERFORMANCE PROFILE AND HEALTH RECOMMENDATIONS**

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**INTRODUCTION:**

Basketball is one of the most popular team sports played worldwide by people of all ages. While previous investigations mainly assessed the performance profile of professional and youth basketball teams (1), little information is available about the demands of senior basketball matches. Therefore, the aims of this study were to assess: i) the senior basketball matches workload and enjoyment; and ii) the differences in workload and fatigue in senior basketball matches played in two consecutive days.

**METHODS:**

Thirteen older adult (age:  $66.6 \pm 2.1$  y) players belonging to three senior basketball teams were recruited for this study. Players' workload was monitored across three matches organized by the Lithuanian Veteran Basketball League (Lietuvos Krepsinio Veteranu Lyga – LKVL) with each player monitored once. Additionally, six players were monitored in 2 matches played in 2 consecutive days with 15.5 h in between matches. The percentage of maximal heart rate (%HRmax) and training workload measured from session rating of perceived exertion (TL-sRPE) were used as internal workload measures, while PlayerLoad (PL) and PlayerLoad per minute (PLmin) were the main external load measures. Additionally, players' fatigue status and enjoyment were measured with previously used scales before and after each match, respectively.

**RESULTS:**

Descriptive analysis showed players spent on average  $41.6 \pm 11.9$  min on court (range = 25.3 – 56.0 min) and showed high internal (%HRmax =  $81.7 \pm 8.1\%$  and TL-sRPE =  $259.7 \pm 71.8$  AU) and external workload (PL =  $269.9 \pm 83.3$  AU; PLmin =  $6.5 \pm 1.3$  AU) with enjoyment values of  $5.9 \pm 2.1$  AU (range = 2.1 – 9.2 AU). When comparing the workload and fatigue status in 2 matches separated by less than 24h, a moderate decrease was shown in PL (ES = -0.72) and PLmin (ES = -0.86) corresponding to a moderate increase in fatigue status (ES = -1.00).

**CONCLUSION:**

This is the first study providing indication about the performance profile of older adult (>65 y) basketball players. Senior basketball matches impose a higher physiological load than those recommended by international guidelines for this age category as previously showed in 55 years-old basketball players (2). Therefore, older adult basketball players are suggested undergoing periodical medical screening test before practicing basketball. Additionally, this study indicated that playing 2 matches in 2 consecutive days provides a moderate increase in fatigue status and decrease in match intensity, suggesting to modify the match schedule allowing a proper rest time or to adopt sound between-match recovery strategies.

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**SELECTING YOUTH SOCCER TALENTS: THE INFLUENCE OF BIOLOGICAL MATURATION ON FITNESS PERFORMANCE**

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**INTRODUCTION:**

Within the talent development process, youth soccer academies aim to offer their players an optimized environment (e.g., high quality training, well-qualified coaches) in order to guide them to future professional level [1]. However, the high selection pressure of gaining an academy place might favour early maturing players with advantages in anthropometry, speed, agility, power, and endurance [2, 3]. Thus, our aim was to compare the biological maturation, as well as anthropometric and fitness characteristics among already nationwide promoted youth soccer players in terms of subsequent academy selection.

**METHODS:**

A battery of anthropometric, speed, coordination, power, and flexibility tests was performed by 322 U14 elite Austrian youth development centre players. Maturity status was assessed from anthropometric measurements using the age at peak high velocity (APHV) method. 169 of those already pre-selected players were subsequently selected into 6 elite youth soccer academies at U15 level. Separate ANOVA ( $p < .05$ ) and eta squared (ES) were calculated to compare maturity status, anthropometric and fitness characteristics between selected and non-selected players. Afterwards, APHV was added as a covariate in ANCOVA ( $p < .05$ ), computed for each fitness parameter separately.

**RESULTS:**

Future academy players were significantly more mature ( $ES=.057$ ), heavier ( $ES=.058$ ), and taller ( $ES=.060$ ) than their non-selected counterparts at U14 level, and showed superior performances ( $p<.05$ ) in almost all fitness tests, except for foot tapping and sit-and-reach. Large ES of .143 was displayed in 20 m sprint, followed by medium to large ES in 5 and 10 split times ( $ES=.084$  and  $.121$ ), 5 x 10 m shuttle sprint ( $ES=.106$ ), medicine ball throw ( $ES=.110$ ), and countermovement jump ( $ES=.059$ ). Small ES were found in hurdles agility run, multi choice reaction test, and drop jump ( $ES=.015-.020$ ).

After controlling for maturity status, the effects of future playing level on fitness performance became smaller across all tests, except for hurdles agility run ( $p<.05$ ;  $ES=.038$ ). Nevertheless, ES remained medium in linear sprint and shuttle sprint ( $p<.001$ ;  $ES=.061-.103$ ), as well as medicine ball throw ( $p<.001$ ;  $ES=.055$ ). Small ES were found in both jump tests ( $p<.01$ ;  $ES=.022-.033$ ), whereas foot tapping, reaction test, and sit-and-reach showed no significant effects of future academy status.

#### CONCLUSION:

Coaches in Austrian youth soccer development programmes favour players with superior fitness performance and an advanced biological maturation. Nevertheless, when controlling for the maturity status, the remaining fitness differences highlight the importance of an adequate athletic level, especially regarding the speed development, during the selection period.

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## EFFECTS OF LONG-TERM AEROBIC TRAINING ON PHYSICAL FITNESS PARAMETERS IN MASTER SWIMMERS

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#### INTRODUCTION:

Aging is a multi-factorial complex process, the basic mechanism of which is not fully known and leads to the disruption of biological functions. There is a decrease in physical activity with aging. Although there are many factors that cause physical regression in the aging process, it is observed that the aging process is slow in active elderly people. Swimming is preferred as a sport for older age groups, with a low injury rate and all muscle groups can be operated.

The International Swimming Federation has defined masters swimming as fitness, friendship, understanding and competition. For this purpose; the determination of physical fitness capacities in master swimmers is important for coping with aging and is thought to be a determinant for healthy aging. Based on this idea, it was aimed to determine the effect of 6-month aerobic training on physical fitness capacities in master swimmers.

#### METHODS:

In this study, 10 male ( $57,0\pm 7,68$  years old) and 10 female ( $53,1\pm 4,64$  years old) master swimmers were participated. Before the study, swimmers' detailed body analyzes have been taken. For male and female swimmers respectively, body height ( $177,3\pm 4,43$  cm;  $167,3\pm 3,0$  cm), body weight ( $85,48\pm 5,8$  kg;  $69,96\pm 7,22$  kg), body mass index ( $27,18\pm 1,51$  kg/m<sup>2</sup>;  $24,97\pm 2,2$  kg/m<sup>2</sup>) data are obtained. As a physical fitness parameters, all swimmers were subjected to 50 m and 200 m front crawl swimming, sit & reach performances (S&R), 1 min crunch (CRH), 30 sec max lat pull down (LPD) for upper body and max leg press (LP) tests for lower body and 3 min step test (3MST). Performance results of all tests requiring the heart rate are also recorded. After the 6-month moderate-intensity aerobic training period (3 days/360 min per week), the tests were repeated and the physical fitness levels were checked again. All swimmers participating in the study were asked to fill in a consent form and the ethics committee permission was obtained. The descriptive statistics were calculated using Statistical Package for Social Sciences (SPSS) v. 25.0. Comparison of pre and post test values of the subjects was done with Wilcoxon paired sample t test. A cut of point in all the statistical analyses has been taken as  $p\leq 0.05$ .

#### RESULTS:

At the end of the 6-month training period; a decrease in basal metabolic rates (BMR) (age-related) and BMI values, an increase in their flexibility, 50M and 200M swimming performances and general physical fitness parameters were observed.

#### CONCLUSION:

In addition to their performances in creating training and racing strategies, master swimmers are important to know about their own capacities and competencies individually, and to prevent risks that may arise during training and competitions. Additionally; it has been tried to reveal the fact that swimming sport can be done for life and its positive effects on quality of life. Being preferred in the elderly population will both affect the health policies of the country positively and will be an important determinant for individual quality aging.

## OP-AP11 Postural balance and stability

### STATIC POSTURAL BALANCE AS A PREDICTOR OF FALLS IN PEOPLE RECEIVING HAEMODIALYSIS: A PROSPECTIVE COHORT STUDY

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#### INTRODUCTION:

People receiving maintenance haemodialysis (HD) for the treatment of stage-5 chronic kidney disease (CKD-5) are at high risk of falls and fall-related injuries. Prospective cohort studies of people receiving HD have reported that 26.3% to 55% experience at least one fall per year, with incidence rates of falls/person-year up to 3.5 times higher than community-dwelling older adults [1]. Static postural balance performance is often impaired in this clinical population and it may be implicated in the aetiology of falling [2]. Therefore, we conducted a prospective cohort study to explore the association between static postural balance and falls in people receiving HD. We hypothesised that higher postural sway would be associated with increased odds of falling.

#### METHODS:

Seventy-five prevalent CKD-5 patients receiving HD (age:  $61.8\pm 13.4$  years) from three Renal Units were enrolled in this prospective cohort study. At baseline, postural balance was assessed with a force platform in eyes open (EO) and eyes closed (EC) conditions. Centre of pressure (CoP) measures of range, velocity and area were taken for the analysis. Falls experienced by study participants were prospectively recorded with a customised falls diary, on a monthly basis, during 12 months of follow-up. Secondary outcomes included timed-up and go, five-repetition sit-to-stand test and the Tinetti falls efficacy scale (FES).

**RESULTS:**

In univariable logistic regression analysis, higher anterior-posterior CoP velocity in EO (OR: 1.11, 95%CI: 1.01-1.23,  $p=0.036$ ), higher medial-lateral CoP range in EC (OR: 1.04, 95%CI: 1.01-1.07,  $p=0.02$ ) and higher medial-lateral CoP root mean square in EC (OR: 1.21, 95%CI: 1.02-1.45,  $p=0.034$ ) were associated with increased odds of falling. After adjustment for predefined demographic and clinical confounders, medial-lateral CoP range in EC (OR: 1.04, 95%CI: 1.00-1.07,  $p=0.036$ ) remained significantly associated with falling. In ROC curve analysis, anterior-posterior CoP velocity in EO exhibited the greatest prognostic accuracy (AUC: 0.69, 95%CI: 0.55-0.82), however this was not statistically different from CoP measures of area and range. None of the postural balance measures exceeded the prognostic accuracy of the FES (AUC: 0.70, 95%CI: 0.58-0.83,  $p=0.005$ ).

**CONCLUSION:**

This prospective cohort study showed that higher postural sway in medial-lateral direction was associated with increased odds of falling during 12 months of follow-up. CoP measures of range, velocity and area displayed similar prognostic value in discriminating fallers from non-fallers. The overall utility of static posturography to detect future fall-risk may be limited in a clinical setting.

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**RELIABILITY OF POSE ESTIMATION DURING POSTURAL BALANCE PERTURBATIONS AT VARIOUS VELOCITIES**

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**INTRODUCTION:**

Motion analysis is a basic biomechanical method used to measure kinematic parameters during human movement. Typically, an array of high-resolution cameras with specific markers and a stable measurement environment are needed for reliable motion analysis. Nowadays, machine learning and different markerless single-camera pose estimation algorithms (1) are becoming more common and may be utilized in movement analysis for instant feedback about sport performances. Little, however, is known about the accuracy of pose estimation at different movement velocities. The purpose of the present study was to compare a state-of-the-art human pose estimation algorithm (AlphaPose) to a more traditional method - Vicon motion analysis - during dynamic balance perturbation perturbations.

**METHODS:**

Dynamic balance was measured in seven subjects (5 women and 2 men). Three different conditions (SLOW, 10 cm/s, 0.5 m/s<sup>2</sup>, MID 16 cm/s, 1.5 m/s<sup>2</sup>, FAST 22 cm/s, 2.5 m/s<sup>2</sup>) were examined when standing on a custom made dynamic balance perturbation platform using 30 cm anterior perturbation displacement. In each condition, 8 perturbations were performed, resulting in a total of 56 perturbations per subject. A high-speed motion capture system (Vicon Nexus 2, Oxford, UK) with reflective markers was used to collect the trajectories of the ankle, hip, knee, and trunk angles. A high-speed camera (Lilin, New Taipei City, Taiwan) was placed to target the middle part of the balance platform, ~4 meters away from it, to collect raw video data. The AlphaPose algorithm (Shanghai Jiao Tong University, Shanghai, China) was used to analyse angles from ankle, knee, and hip joints along with the trunk angle.

**RESULTS:**

When measured with Vicon, ankle, knee, hip, and trunk angles changed  $2.1\pm 1.3 - 3.1\pm 1.2$  degrees,  $8.6\pm 5.0 - 13.6\pm 11.6$  degrees, and  $15.0\pm 7.2 - 24.2\pm 13.1$  degrees in SLOW, MID, and FAST perturbations, respectively. The absolute average difference between AlphaPose and Vicon was  $0.9\pm 0.8 - 2.1\pm 1.2$  degrees,  $1.6\pm 1.5 - 3.2\pm 2.9$  degrees, and  $2.3\pm 3.0 - 6.1\pm 4.4$  degrees in SLOW, MID, and FAST conditions, respectively. Ankle, knee, hip, and trunk angle ICC values were POOR to MODERATE ( $r=0.221$   $p=0.135 - r=0.744$   $p<0.0001$ ) in SLOW, EXCELLENT ( $r=0.902 - 0.976$ ,  $p<0.0001$ ) in MID, and MODERATE TO EXCELLENT ( $0.715 - 0.959$   $p<0.0001$ ) in FAST.

**CONCLUSION:**

These results suggest that AlphaPose is a potential tool for automatic movement analysis when movement velocity and joint angle changes are high enough. Smaller joint angle changes with slow perturbation velocity were not detected as accurately by the AlphaPose algorithm. In the future, the effects of background, higher movement velocity of the subject, subject's anatomical characteristics (e.g. height) and data processing, such as different filtering options should be investigated in more detail.

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**POSTURAL STABILITY IN ATHLETES: THE ROLE OF SPORT DISCIPLINE**

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**INTRODUCTION:**

As shown by various studies, standard postural tests increase postural stability in athletes engaged in certain sports (4). Many studies failed to find any differences in routine double-support postural tests, with EO and EC, between non-athletes and athletes (5). On the contrary, mid-level and especially highly skilled athletes in different sports often showed reduced postural stability in normal postures (3). The studies compared the postural balance of athletes and control subjects and did not provide a complete picture of relationship between engagement in sports and the level of postural stability. This requires extensive analysing postural stability in various sports (1, 2). We can conclude that the issue of postural balance in athletes engaged in various sports is not well understood. This study compares the postural stability in bipedal stance with eyes-open (EO) and eyes-closed (EC) among athletes ( $n=936$ , age: 6-47 years, females/males: 484/452) engaged in different sports and non-athlete controls.

**METHODS:**

All athletes were divided into 13 groups based on movement coordination similarities: Team Sports Played with Hands ( $n=90$ ), Shooting ( $n=72$ ), Boxing ( $n=106$ ), Tennis ( $n=57$ ), Alpine Skiing ( $n=49$ ), Figure Skating ( $n=86$ ), Football ( $n=70$ ), Rowing ( $n=24$ ), Wrestling ( $n=71$ ), Speed Skating ( $n=61$ ), Cross-Country Skiing ( $n=37$ ), Running ( $n=45$ ), Gymnastics ( $n=168$ ), and Control ( $n=225$ , age: 7-30 years, females/males: 97/128). Center of pressure (COP) sway area (AS) and velocity (VCP) were analysed while standing in a bipedal stance with EO and EC on a stable stabiloplatfom (50 Hz).

**RESULTS:**

According to Tukey's HSD test, the order of VCP-EO increase in athletes vs Control was as follows: Shooting ( $-11.3\%$ ,  $p<0.0001$ ) < Football ( $-0.4\%$ ,  $p<0.0001$ ) < Boxing ( $-8.7\%$ ,  $p<0.0001$ ) < Cross-Country Skiing ( $-7.2\%$ ,  $p<0.0001$ ) < Gymnastics ( $-7.0\%$ ,  $p<0.0001$ ) < Running ( $-6.9\%$ ,  $p<0.0001$ )

< Wrestling (-6.3%,  $p < .0001$ ) < Team Games Played with Hands (-6.8%,  $p = .2E-04$ ) < Tennis (-5.5%,  $p = 0.0004$ ) < Alpine Skiing (-5.4%,  $p = 0.002$ ) < Rowing (-5.0%,  $p = 0.194$ ) < Speed Skating (-4.7%,  $p = 0.004$ ) < Figure Skating (-3.6%,  $p = 0.034$ ).

The order of VCP-EC increase in athletes vs Control, based on Tukey's HSD test, was as follows: Shooting (-10.7%,  $p < 0.0001$ ) < Football (-8.5%,  $p < 0.0001$ ) < Boxing (-7.5%,  $p < 0.0001$ ) < Cross-Country Skiing (-6.5,  $p = 0.045$ ) < Wrestling (-6.1%,  $p = 0.003$ ) < Gymnastics (-5.8%,  $p < 0.0001$ ) < Running (-3.7%,  $p = 0.72$ ) < Team Games Played with Hands (-3.5%,  $p = 0.33$ ) < Tennis (-2.8%,  $p = 0.91$ ) < Alpine Skiing (-2.5%,  $p = 0.97$ ) < Speed Skating (-2.5%,  $p = 0.95$ ) < Rowing (-2.0%,  $p = 1.0$ ) < Figure Skating (-1.2%,  $p = 1.0$ ).

#### CONCLUSION:

Postural stability is better in athletes than non-athletes, in particular in shooters. This may be ascribed their sport-specific training.

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## ABSOLUTE VS. RELATIVE VALUES OF POWER IN ASSESSING STANDING TRUNK ROTATION PERFORMANCE UNDER VARIOUS LOADING CONDITIONS

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#### INTRODUCTION:

The importance of power to weight as a determinant of performance in sports involving trunk rotations under various loading conditions is unclear. We were interested in investigating whether the body weight has a relationship with rotational power of the trunk, namely when exercising in a standing position with higher loads.

#### METHODS:

A group of 138 athletes (age  $23.4 \pm 4.1$  y, height  $182.5 \pm 8.9$  cm, body mass  $91.4 \pm 13.6$  kg), who perform standing and sitting trunk rotations in their sports (boxing, canoeing, hockey, judo, karate, kayaking, tennis, and wrestling), completed two trials of trunk rotations at each side in both standing and sitting positions with a barbell of different weights (increasing from 5.5 kg up to a weight at which maximal values of power were achieved) placed on their shoulders. The power produced during trunk rotations was evaluated using the FiTRO Torso Premium.

#### RESULTS:

Small to moderate correlations were revealed between the body weight and peak power as well as mean power in the acceleration phase of seated trunk rotations at weights from 5.5 to 20 kg ( $r$  ranged from 0.36 to 0.45 and from 0.27 to 0.39 respectively,  $p > 0.05$ ). Furthermore, the body weight moderately correlated with peak and mean values of power produced during standing trunk rotations at weights of 5.5 kg ( $r = 0.43$ ,  $p = 0.133$  and  $r = 0.34$ ,  $p = 0.193$  respectively), 10.5 kg ( $r = 0.48$ ,  $p = 0.087$  and  $r = 0.40$ ,  $p = 0.155$  respectively), and 15.5 kg ( $r = 0.65$ ,  $p = 0.043$  and  $r = 0.51$ ,  $p = 0.060$  respectively). However, there were high correlations between these variables when higher weights of 20 kg ( $r = 0.85$ ,  $p = 0.015$  and  $r = 0.77$ ,  $p = 0.036$  respectively) and 25 kg ( $r = 0.91$ ,  $p = 0.007$  and  $r = 0.83$ ,  $p = 0.022$  respectively) were used.

#### CONCLUSION:

Non-significant correlations between the body weight and muscle power during seated trunk rotations are in agreement with findings by Lindsay et al. (1) who reported poor and moderate correlations between the body weight and work or torque produced at both the dominant ( $r = 0.34$ ;  $r = 0.44$ ) and non-dominant side ( $r = 0.28$ ;  $r = 0.44$ ) in golfers during isokinetic torso rotation measurements in a sitting position. Similar relationships between these variables during standing trunk rotations with lower weights were also observed. However, significant correlations between the body weight and peak and mean values of trunk rotational power with weights  $\geq 15$  kg and  $\geq 20$  kg respectively were found. This demonstrates the importance of determining the relative values of power when trunk rotation performance in a standing position is evaluated. The power expressed relative to body weight seems to be more important measure than absolute power for most athletes to consider, namely for those whose performance depends heavily on rotational movements of the trunk while standing.

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## OP-AP12 Talent identification

### MUSCULAR POWER IN CADET KARATEKAS MAY HELP TO PREDICT FUTURE INTERNATIONAL SUCCESS IN JUNIOR CATEGORY

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#### INTRODUCTION:

Karate (specifically, kumite modality) will be included in the Dakar 2022 Youth Olympic Games, in which athletes under 18 years can compete. Different fitness and anthropometric markers in young athletes have been associated to a higher likelihood of elite success in senior category [1]. In this study we aimed to identify whether fitness and anthropometric markers in cadet karatekas (14-15 years) could also predict future international success in the junior category (16-17 years).

#### METHODS:

Data from all cadet kumite specialists that participated in the training camps of the Spanish National Karate Federation between 1999 and 2016 was analyzed (157 male, aged  $15.3 \pm 0.6$  years; 81 female, aged  $15.4 \pm 0.5$  years). Binary logistic regression models were built in order to verify whether fitness (aerobic capacity, upper and lower-body muscle power, coordination, agility and flexibility) and anthropometric variables (height, weight, body mass index and body fat percentage) could predict future sport success (i.e., achieving a medal in World or European Championships in junior category).

**RESULTS:**

Cadets that later achieved an international medal in the junior category showed an overall higher fitness level and a better anthropometric profile. Significant differences were observed in lower-body muscle power (standing long jump:  $228.1 \pm 15.8$  vs  $217.5 \pm 16.3$  cm,  $p = 0.036$ ) for male karatekas and in upper-body muscle power (overhead 3 Kg ball throw:  $6.3 \pm 1.5$  vs  $5.0 \pm 0.7$  m,  $p = 0.002$ ) for female ones. These variables were included in the regression models for boys and girls respectively. Binary logistic regression models included 115 boys (12 international / 103 national medalists) and 48 girls (4 international / 44 national medalists). Both models showed significant capacity to predict success in junior category (model 1 male: Chi-square = 4.83,  $df = 1$ ,  $sig. = 0.028$ ; model 2 female: Chi-square = 7.11,  $df = 1$ ,  $sig. = 0.008$ ).

**CONCLUSION:**

Upper and lower-body muscle power seems to be the key fitness markers associated with sport success in young karate athletes, a finding that is in line with previous studies carried out in elite karatekas in senior category [1]. In conclusion, physical fitness in cadet category can predict karate success in junior category. This information may be used in talent detection programs.

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**ANALYSIS OF POTENTIAL MARKERS OF SUCCESS IN PERFORMANCE FOR YOUNG SWIMMERS.**

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**INTRODUCTION:**

One of the most significant predictors of swimming performance is anthropometry, since the height of the body defines longer limbs to perform fewer strokes with a given moment of strength value [1]. However, other technical aspects such as the stroke mechanics or the sports level can influence these results [2]. The aim of this study was to explore the role played by different variables to predict potential markers of success in young swimmers.

**METHODS:**

A group of young swimmers [(boys,  $n = 35$ ; age: 12-13), (girls,  $n = 32$ ; age: 11-12)] included by their personal achievements in a Monitoring Program (MP), were tested in: i) strength tests: Squat Jumps (SJ) and Pull-Ups (PU) from what velocity, power, force and jump height\* were obtained through a linear encoder (\* for SJ only); ii) anthropometrics: Height (H) and arm span (AS), and; iii) swimming tests: Underwater Swimming Velocity (USV) and Time to 15 and 50m (T15-50m). The relationships between variables were studied by Pearson correlation coefficient ( $r$ ). One year later, ten of those boys and girls were included again in the MP by the same criteria, but the others were excluded. A non-parametric independent t test was applied to determine if the swimmers included again had previously presented any particular marker of potential success with respect to those not selected. The statistical analyses were conducted on SPSS ( $p < 0.05$ ).

**RESULTS:**

In boys, the jump height and its maximal force correlated with T15m ( $r = -0.399$ ,  $p = 0.018$ ) and USV ( $r = 0.419$ ,  $p = 0.014$ ), respectively. H and AS correlated with T50m ( $r = -0.550$ ,  $p = 0.001$ ;  $r = -0.583$ ,  $p = 0.000$ ) and T15m ( $r = -0.392$ ,  $p = 0.020$ ;  $r = -0.411$ ,  $p = 0.014$ ). In girls, the maximal force of the jump correlated with T50m ( $r = -0.388$ ,  $p = 0.028$ ) and T15m ( $r = -0.416$ ,  $p = 0.018$ ). H correlated with T50m ( $r = -0.389$ ,  $p = 0.028$ ), T15m ( $r = -0.389$ ,  $p = 0.028$ ) and USV ( $r = -0.447$ ,  $p = 0.010$ ); and AS correlated with T50m ( $r = -0.359$ ,  $p = 0.043$ ) and T15m ( $r = -0.351$ ,  $p = 0.049$ ). T50m and T15m correlated between them in both genders ( $p < 0.001$ ).

The boys included again in the MP had presented better values in T15m ( $7.96 \pm 0.39$  vs  $8.22 \pm 0.51$  s) and USV ( $1.15 \pm 0.14$  vs  $1.11 \pm 0.10$  m/s) than not included. In girls, those values were better in T50m ( $31.39 \pm 0.56$  vs  $33.05 \pm 1.44$  s), T15m ( $8.31 \pm 0.48$  vs  $9.09 \pm 0.44$  s) and several velocity and power-based variables collected from the SJ and PU ( $p < 0.05$ ).

**CONCLUSION:**

Superior athletic level and anthropometry seem to be predictors of performance of young swimmers. However, the boys included again in the MP had not presented better values in the physical skills but in the technical (T15m and USV), compared to not selected. In girls, the combination of technical skills (T15m and T50m) and high athleticism were the potential markers of such success. Therefore, swimming programs for youth focused on high performance should include the specific development of those skills.

**MATURATIONAL EFFECTS ON SPRINTING FORCE PRODUCTION CAPACITIES IN ELITE MALE SOCCER PLAYERS**

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1 : UJM ; 2 : USMB ; 3 : ASSE

**INTRODUCTION:**

Sprint and acceleration capabilities are part of core capacities in soccer. If sprinting acceleration performance have been widely shown to be improved with maturity offset (1), no biomechanical information's are available to explain the horizontal force production properties underlying this performance change. The aim of this study was thus to investigate the influence of age and maturation upon sprinting force- velocity-power (FVP) propulsion characteristics.

**METHODS:**

One hundred and ninety-two players of the Association Sportive de Saint-Etienne (6 to 23 years old) took part in this study and performed two maximal 30-m sprints. The maturity offset was estimated for each player from standing height, seated height and body mass. From the instantaneous velocity recorded by a radar device, Force- and Power-velocity relationships were determined from the best sprint (shortest time to cover 20-m) (2). From the F-V curve, maximal theoretical force (F0), maximal theoretical velocity (V0), Slope of the linear F-v relationship (SFv) and maximal power (Pmax) were calculated. The mechanical effectiveness of force application onto the ground was computed as the maximal value (RFpeak) and the rate of decrease with velocity (DRF) of the ratio of horizontal-to-resultant force characterising the maximal ability to orient force effectively onto the ground and the ability to maintain this effectiveness despite the velocity increase (3). One-way ANOVAs and regressions between maturation offset and mechanical variables were performed.

**RESULTS:**

One-way ANOVAs revealed significant effects of maturity offset on anthropometrics, sprint performance and FVP mechanical properties. The sprint performance throughout the maturity offset is a non-linear process. The increase in sprint performance was correlated with an increase in Pmax. The latter is explained more by an increase in V0 rather than in F0. SFv, describing the athlete's individual balance between force and velocity capabilities, showed FV profiles which tend more to profiles oriented towards velocity capabilities (capacities to

produce horizontal force at high velocities) with maturity offset. The increase in F0 and V0 were partly due to improvement in mechanical effectiveness at both low (RFpeak) and high (Drf) speed, notable until 15 years old.

#### CONCLUSION:

The present study brought new insights into the effect of maturity offset on sprint performance and notably horizontal force production capacities, which can be useful information for coaches and specialists of physical education. In addition, these results may constitute a normative database in order to determine strength and weakness in sprinting force production abilities in young soccer players.

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## OP-AP13 Competition demands

### PERFORMANCE ANALYSIS DURING EXCLUSIONS IN FEMALE HANDBALL ACCORDING TO THE FINAL RANKING AT RIO 2016 OLYMPIC GAMES

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#### INTRODUCTION:

Studies of performances indicators in handball have been increased in the last decade due to the relevance in the increment of the knowledge in this field (1). The relation of the performance with the final ranking of teams has been studied due to the relevance of knowing how teams best ranked perform (2). Exclusions in handball derive in inequality situations, especially important for those teams in inferiority (3).

The aim of the present study was to determine teams offensive performance indicators during exclusions in relation to the final ranking obtained in the tournament.

#### METHODS:

Sample consisted in all 38 matches from Rio 2016 Female Handball Olympic Games played by 12 national teams. A total of 328 exclusions occurred during those matches. Matches ended in a draw were excluded. Observational methodology procedures were followed to register the actions. The research team reviewed the videos and collected the data using the software Lince 1.1. Chi square test was applied to identify associations between the variables.

#### RESULTS:

Results showed that 1026 finalization actions of numerical inequality, as a consequence of exclusions, took place during the tournament (570 in conditions of superiority and 456 in conditions of inferiority). Statistical significant association ( $p < 0.01$ ) was found between teams final ranking and numerical inequality situations (superiority and inferiority). Winners ranked 1 to 8 registered more finalizations during superiority, and losers 5 to 12 during inferiority. No significant statistical association ( $p > 0.05$ ) was found in any particular final ranking place during superiority. Losers showed less percentage of turnovers in all 3 groups of places, and winners scored more goals. Teams final ranking presented statistical significant associations ( $p < 0.01$ ) while being in inferiority. Winners showed a better attacking offensive efficacy but losers presented less percentage of turnovers in places 5 to 12. Losers tended not to score their throwing. Playing with empty goal happened in the 33,8 % of the total. No significant statistical association ( $p > 0.05$ ) was found between teams final ranking and taking the goalkeeper out. Winner teams ranked 1 to 4 showed similar percentage of attacking efficacy, turnovers and throwing not ended in goals when playing with and without empty goal, while losers ranked 1 to 4 doubled their turnover percentage when taking the goalkeeper out.

#### CONCLUSION:

Winner teams ranked 1 to 8 scored more goals than losers in both superiority and inferiority. Playing inferiority with goalkeeper at goal or not, showed not important difference in winner teams ranked 1 to 4 performance indicators (percentage of attacking efficacy, turnovers and throwing not ended in goals).

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### HIGH INTENSITY ACTIVITIES ANALYSIS OF ELITE U17 FOOTBALL PLAYERS OF GREEK SUPERLEAGUE

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#### INTRODUCTION:

Modern football is characterized by increased physical, technical and tactical requirements (Anderson, 2008). Despite the fact that low-intensity aerobic activities are predominant in the overall energy consumption, the capacity of high-intensity anaerobic performance (e.g. sprinting, high-intensity running) is crucial to determine the outcome of a match (Bradley et al., 2009). Purpose of the current study was to deduce the activity profiles of elite youth players with emphasis to high intensity activities, in order to contribute to the optimization of high intensity training programs.

#### METHODS:

Data were extracted from 15 matches of an elite youth soccer team of U17 division of Greek Superleague, from players participating in the whole 90 minutes of the matches. Measurements were conducted with GPS system (Vis Track, Impire). The examined variables were: a) total distance covered (m), b) distance covered in sprinting (speed 22,68 km/h) and c) in fast runs (18,0-22,68 km/h). Statistical analysis was conducted with descriptive statistics (mean, SD) and r-Pearson tests ( $p < 0.05$ ) and ANOVA analysis.

#### RESULTS:

Statistically significant discrimination ( $F(4,89) = 11.069, p = 0.000$ ) within playing positions was found in total distance covered with CM's and FB's dominating (CM = 10017,60  $\pm$  637,301 m, FB = 9558,10  $\pm$  601,246 m, FW = 9468,57  $\pm$  568,519 m, CF = 9358,75  $\pm$  557,098 m, CB = 8874,00  $\pm$  646,903 m). Furthermore, significant difference was found in sprinting ( $F(4,89) = 29.621, p = 0.000$ ) ( $> 22,68$  km/h), in which FW's, CF's and FB's presented greater values (FW = 397,71  $\pm$  172,394 m, CF = 242,13  $\pm$  115,101 m, FB = 186,43  $\pm$  51,929 m, CB = 122,84  $\pm$  58,284



m, CM = 74,32 ± 40,194 m). Regarding the fast runs (18,0-22,68 km/h), results unveiled congruent distinctions among playing positions (F(4,89) = 11.038, p=0.000) (FW = 398,57 ± 65,056 m, CF = 360,31 ± 62,191 m, FB = 324,90 ± 63,389 m, CB = 280,56 ± 69,262 m, CM = 257,24 ± 66,025 m).

**CONCLUSION:**

From the findings of the present study is certified that high intensity activities are executed in major by attackers and the wingers (defenders and forwards). Consequently, training process has to provide special high intensity training stimuli according to playing position needs, in order to sustain the homogeneity of the team.

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**INTER AND INTRA-RATER RELIABILITY OF THE KATA PERFORMANCE ANALYSIS TEMPLATE**

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**INTRODUCTION:**

Karate kata are executed as a specified routine of various technical movements, while attempting to maintain perfect form. With the new kata evaluation procedure created by the World Karate Federation for the 2020 Olympic Games seven judges will evaluate the kata performances with scores given according to the technical and athletic presentation of the katas. The aim of this study was to devise a valid analysis system for the assessment of the movement characteristics of competitive kata performance and to assess its intra- and inter-rater reliability using analysts of varying experience of the sport and performance analysis.

**METHODS:**

The most frequently performed kata during top-level karate tournaments "Annan" (Augustovicova, 2018) was analysed. The kata was performed by the World champion at the World Karate Championships 2016 during the final match and it was analysed on two occasions one week apart by the lead author (LA), a professional kareteka (PK) and a karate referee (KR). Each individual observer was provided the operational definitions of the performance indicators, example kata clips and, if necessary, instructions detailing the method of 'tagging' using a computerized analysis software (LongoMatch).

The performance indicators included fast and slow transitions (same place, step, shift, rotation, and jump), stance height (high, middle and low), lower limb techniques (high, middle, low kick) and fast and slow upper limb techniques (punch, strike, block, pull-grab-throw).

Data were subjected to intra-rater reliability assessment using Cohen's Kappa coefficient and calculating the 95% CI. For inter-rater reliability of all rater pairs (LA-PK, LA-KR, KR-PK) the arithmetic mean of Kappa was used (Light, 1971). The Kappa coefficient was interpreted as: 0.01–0.20 "none to slight", 0.21–0.40 "fair", 0.41– 0.60 "moderate", 0.61–0.80 "substantial", and 0.81–1.00 "almost perfect" agreement (Cohen, 1960).

**RESULTS:**

The intra-rater reliability was found to be "almost perfect" in all raters (LA K = 0.91 [95% CI: 0.90-0.92]; PK K = 0.94 [95% CI: 0.93-0.95]; KR K = 0.94 [95% CI: 0.93-0.95]) whilst the inter-rater reliability for all pairs of comparisons was K = 0.84±0.03 ("almost perfect" agreement).

**CONCLUSION:**

Both intra- and inter-rater Kappa coefficients were almost perfect. This study has demonstrated that a novel performance analysis template can yield consistent (reliable) observations of the key movement characteristics occurring during kata. Moreover, the template can be used reliably by different operators with varying experiences of performance analysis to determine the features of a kata. Future work is now underway to identify specific traits associated with a successful performance which might streamline analysis of kata performance.

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**A VIEW OF TEAM HANDBALL BY PASSES, FOULS, FAILURES, AND SUCCESSES**

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**INTRODUCTION:**

Several attempts have been made to explain team handball based on objectively recordable information, with the aim to help coaches to improve the performance of their team. This paper describes a new approach which focuses on two very basic events during attacks of team handball: passes and sanctioned fouls. The paper will present results based on data collected in matches of the first German Team Handball league (HBL). Some will just confirm already known (or at least previously guessed) properties, while some other might be counter intuitive.

**METHODS:**

By using self-developed mobile apps, we have recorded the data of 67 games of the HBL consisting of 6.639 attacks and we have recorded additional matches for verification such that we have data of 10.234 attacks in total.

The data has been stored in a relational database which we used for the application of statistics and data mining methods. Besides just looking at the aggregated numbers, we did also investigate the sequences of events and sequence specific effects. Particularly, we investigated whether the winner team can be predicted during matches.

**RESULTS:**

There are some basic results which somehow characterize matches of the HBL:

- A match consists in average of 50 attacks of each team.
- In average 1.300 passes are played in a team handball match.
- There are approximately 28 successful attacks (goals) per team und 14 non-successful attempts. Around 8 attacks end with a ball handling error or a rule violation.

Looking at the outcome of attacks based on the two dimensions "number of passes" and "number of fouls" we have found that more than 87% of all attacks are finished with none or one sanctioned foul and more than 92% of the attacks consist of less than 25 passes. More than a quarter of the goals result from attacks with less than 5 passes and without a sanctioned defense foul. It is surprising that only about 10% of goals are scored in attacks having between 6 and 10 passes, which might be caused by the exchange of players when switching from defense to offense mode.

There are far more results, which will be presented in the full paper. Particularly, we will present a view on the effectiveness of the different segments of number of passes and number of fouls. Furthermore, we will present rules to predict whether a team will lose a match with an accuracy up to 93%.

#### CONCLUSION:

It is surprising that the number of sanctioned fouls is relatively low in team handball. Usually that is perceived differently when watching games. Furthermore, scoring goals with a low number of passes is significantly important to win a match. There is a peak in the number of passes per attack up to which the teams are effective. Beyond that peak, the effectiveness goes down significantly.

One conclusion is obvious: The connection between passes, fouls, and the success of attacks is not linear. This explains why humans have real difficulties to "understand" team handball.

### ANTHROPOMETRIC, PHYSICAL, PHYSIOLOGICAL AND PERFORMANCE PROFILES OF INTERNATIONAL INSHORE SAILORS.

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#### INTRODUCTION:

The sailing tour de France (TDF) is one Europe's major annual inshore sailing event. The first TDF was held in 1978. For over 40 years, this competition has allowed some of the world's best sailors to compete along the French coastline. Currently, normative data analyzing the physiological demands of various sailing events is scarce. More research is necessary in order to rationalize sports training and to prepare for great events such as, for instance, the sailing tour de France. Hence, it would turn out to be relevant to analyze the physiological demands of such a competition.

#### METHODS:

Professional international inshore sailors (N= 21; mean  $\pm$  SD; age = 23.81  $\pm$  4.18 years; height = 179.32  $\pm$  7.30 cm; body mass = 74.78  $\pm$  6.56 kg) were assessed in the final preparation phase leading up to the 2019 TDF. Subjects were signed up for 3 testing sessions: a) anthropometry b) physical and physiological and c) GPS tracking. Anthropometric characteristics were measured in the following order: weight, height, sitting height, wingspan, skinfolds and body girths. Physical testing included handgrip strength, upper body pulling power, maximal hip extension strength, vertical jump height, anaerobic power and aerobic capacity. An athlete was categorized as "successful" (SA) if his boat finished the tour in the Top 5 rankings. Less successful athletes (LSA) ranked between the 6th and 23rd rankings.

#### RESULTS:

No significant differences were observed in anthropometric parameters. Successful sailors had stronger hand grip strength (ES=0.82) and isometric mid thigh pull relatively to bodyweight (ES=0.93) and exerted faster bench pull power (ES=1.18) than their less successful counterparts. The results of GPS data analysis demonstrates that significant differences were observed in terms of average speed (ES=1.78), maximal speed obtained (ES=0.86) and distance covered per race (ES=-1.3) between SA and LSA. SA exhibited a leg participation at 55.5  $\pm$  1.8 counts while LSA at 49.5  $\pm$  2.4. The difference between SA and LSA was significant (p=0.001).

#### CONCLUSION:

The aim of this present study was twofold. Firstly, our objective was to describe the anthropometric, physical and physiological profiles of elite level sailors participating in the TDF. Secondly, we attempted to identify the variables that might separate SA from LSA. To the best of our knowledge, this is the first study to assess the anthropometric, physical and physiological profiles of TDF sailors while comparing SA with LSA. Evidence suggests that SA can be distinguished from LSA in terms of hand grip strength of the dominant hand, isometric mid-thigh pull and force-velocity in pulling with light loads (20 kg) in lying position.

## OP-AP14 Sport technology and data analysis

### ADOPTING IMU SENSOR IN CYCLING POSTURE ANALYSIS: A PILOT TEST

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#### INTRODUCTION:

Cycling posture is one of crucial factor related to performance and injury 1. Studies about the impact of cycling postures were commonly found in the literature such as upright Vs supine 2, seated Vs standing 3, 4, different seat heights 5, 6, and different trunk angles 7. Muscular performance 8, oxygen consumption 2, ventilator response 9, and power output 7 were measured in order to identify the effect of cycling posture on exercise performance. In the cycling practice and competition, heart rate, cycling speed, cycling cadence were used to reflect the performance of cyclist. However, limited information about cycling posture was used in training or competition even through it is one of crucial factor related to cycling performance. This study aimed to investigate the use of inertial measurement unit (IMU) sensor in cyclist posture analysis.

#### METHODS:

The use of IMU sensor for trunk inclination measurement during cycling was investigate in this study. One subject was asked to perform the cycling exercise on the Wattbike at constant power output (87-92W), cadence (70-71rpm), heart rate (111-113bpm) under different cycling postures, i.e. cycling with upper handle, lower handle and TT bar handle. IMU was located at P1 (T1-T2), P2 (T3-T4), P3 (T5-T6), P4 (T8-T9), P5 (T11-T12), P6 (L1-L2), P7 (L3-L4), P8 (L5-S1) for the trunk inclination angle measurement during cycling exercise with using different handles. Vicon motion capture system with full body model was employed for cycling body movement analysis. Trunk inclination angle was measured from both IMU and Vicon motion system for further comparison so as to identify the optimal location of IMU sensor for cycling posture measurement.

#### RESULTS:

For the cycling exercise with upper handle at Wattbike, the reading from IMU showed 18, 20, 22, 27, 42.5, 47, 58 and 67deg at P1-8 respectively. Data from Vicon system indicated that trunk angle between horizontal level was 55.2deg. While having cycling exercise with lower

handle at Wattbike, the reading from IMU showed 6, 7, 8, 11.5, 29, 31, 41 and 51deg at P1-8 respectively. Data from Vicon system indicated that the trunk angle between horizontal level was 33.9deg. In cycling exercise with TT bar handle at Wattbike, the reading from IMU showed 1, 1.5, -4.5, 1, 16.5, 17, 26 and 44deg at P1-8 respectively. Data from Vicon system about the trunk angle between horizontal level was 13.5deg. The comparison of data between IMU and Vicon system indicated that the optimal position of IMU sensor should be P7 for upper handle, P6 for lower handle and P5 for TT bar handle. Analysis of Pearson correlation indicated significant correlation between trunk angles from IMU at P6 and Vicon motion system (Pearson correlation coefficient = 1,  $p < .05$ ).

**CONCLUSION:**

The results of this pilot study indicated that to put IMU sensor at P6 (L1-L2) can identify the cycling posture (trunk inclination) when using upper, lower and TT bar handle in cycling exercise at Wattbike.

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**USING MICROTECHNOLOGY TO QUANTIFY THE LOAD OF HIGH-INTENSITY ACTIVITIES DURING BASKETBALL GAMES**

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**INTRODUCTION:**

Load monitoring in basketball has gained much attention in recent years, as it allows to develop specific training programs, optimizing physical performance and reducing the risk of injury and overreaching [1]. Whilst time-motion analysis (TMA) and microtechnology are the most commonly adopted tools for load quantification [2], information regarding the load associated with specific activity patterns during competition is still limited. Understanding the external load imposed on players of different playing positions performing high-intensity activities during basketball games may provide relevant insight for developing appropriate training strategies. Therefore, the aim of this study was to quantify the external load associated with high-intensity activities during basketball games, and to compare such values between different activity patterns and playing positions.

**METHODS:**

TMA was performed on 11 male basketball players (6 backcourt, 5 frontcourt) competing in the Lithuanian 3rd division during 3 in-season official games. High-intensity activities including sprints, high-intensity specific movements (HSM) and jumps were identified using a manual frame-by-frame software. Contextually, PlayerLoad (PL) and PlayerLoad/min (PL/min) were calculated after collecting inertial data using triaxial accelerometers. The TMA and accelerometer datasets were then aligned, and the PL and PL/min were calculated for each activity. Linear mixed models were used to examine differences in PL, PL/min and mean duration between activity patterns and playing positions.

**RESULTS:**

Lower PL values were found for jumps ( $0.22 \pm 0.16$  AU) compared with sprints ( $0.44 \pm 0.43$  AU;  $p < 0.001$ , effect size [ES] = 0.68) and HSM ( $0.44 \pm 0.44$  AU;  $p < 0.001$ , ES = 0.58). Greater PL/min values were found for sprints ( $21.69 \pm 14.05$  AU/min) compared with jumps ( $18.70 \pm 13.43$  AU/min;  $p = 0.023$ , ES = 0.22). Jumps ( $0.72 \pm 0.11$  s) displayed lower mean duration values than sprints ( $1.18 \pm 0.60$  s;  $p < 0.001$ , ES = 1.10) and HSM ( $1.32 \pm 0.93$  s;  $p < 0.001$ , ES = 0.81), with HSM lasting longer than sprints ( $p = 0.002$ , ES = 0.17). With respect to playing positions, backcourt players showed higher average duration values for jumps than frontcourt ( $0.73 \pm 0.10$  vs  $0.70 \pm 0.12$  s;  $p < 0.001$ , ES = 0.33). No other significant differences were found between playing positions.

**CONCLUSION:**

The current findings suggest that distinct high-intensity activity patterns performed during basketball games are characterized by different levels of external load. Practitioners should consider such discrepancies when developing training sessions, as different proportions of each activity pattern are likely to produce different total load during sessions with the same duration. The lack of positional differences observed (except for the duration of jumps) may be due to the playing positions categorization used in the present study.

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**QUANTIFYING RANDOM ERROR IN ELECTRONIC PLAYER TRACKING SYSTEMS (EPTS) IN DIFFERENT STADIA**

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**INTRODUCTION:**

Electronic performance and tracking systems (EPTS) include optical, global (GPS) and local (LPS) systems and are routinely used to monitor velocity of players. Optical systems require multiple camera installations mounted at specific heights to capture footage across a playing surface. GPS and LPS systems rely on a network of satellites or local static stations that transmit signals to a receiver worn by the players. Sports organisations should consider how the local environment may cause errors in EPTS data. The aim of this study was to investigate random error differences for optical, LPS, and GPS systems between two football stadia.

**METHODS:**

A 30 x 30 m 3-D motion capture system (36 cameras, VICON Vantage V5, V8, and V16, sampling rate: 100 Hz) was positioned near the centre of the football pitch at two stadia (Miniestadi and Camp Nou). Five spherical reflective markers (28 mm diameter) were attached to players' shoulders, hips, and sacrum. Fifty-six players participated in a football circuit (walking, jogging, 20 m sprint, and change of direction), 2v2, 3v3, and a 5v5 small-sided game. Two optical, two GPS, and one LPS system measured player velocity. EPTS and VICON data

were down-sampled to 10 Hz to facilitate comparison of player velocities across all activities. Root mean squared difference (RMSD) was used to determine the error between EPTS and VICON at both stadiums.

**RESULTS:**

All EPTS velocity exhibited lower RMSD against VICON at Camp Nou compared to Miniestadi (0.01-0.16 m.sec-1). Optical systems had a higher RMSD range (0.14- 0.34 m.sec-1) compared to GPS (0.11-0.25 m.sec-1 and LPS (0.11 – 0.18 m.sec-1) at both stadiums.

**CONCLUSION:**

Between stadium differences were found for all EPTS, with less error at Camp Nou. Optical systems had the highest error compared to LPS and GPS, which may be caused by the height of camera mount, camera quality, and distance from the playing surface (1). Similarly, LPS accuracy is dependent on static station installation within a stadium, with differences in stadium installation potentially accounting for observed errors (1). GPS systems are flexible with no installation between locations, however connection ability, satellites in range, and the size of roof structures and stadium surroundings can potentially occlude the system's ability to track players effectively (1).

Conclusions: Sports organisations should consider the consistency of EPTS across different locations when purchasing EPTS.

## THE INFLUENCE OF FOUR FEATURE SETS ON THE ACCURACY OF BASKETBALL MOVEMENTS RECOGNITION

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**INTRODUCTION:**

The automated recognition of sport-specific movements benefits basketball players to monitor their performance and physiological workload[1]. In fact, there are already bracelet products based on the sensor attached to the wrist for basketball movements recognition. In this paper, we intended to discuss two aspects that may affect the recognition accuracy such products. First, to compare the effect of the number of sensors (i.e., sensors attached to one or two wrists). Second, to investigate the influence of data types: acceleration vs. pose, which means the position of the wrist relative to the chest[2].

**METHODS:**

We recruited 29 right-handed professional basketball players (23 males, 6 females) from Beijing Sport University. Each player performed the selected two shooting movements (layup and set shot) and two defensive movements (block shoot and triple vertical jump), with the optical markers on their wrists, toes and chest. Their motions were captured by Opitrack (Hz =200). We determined the start and end frame for each movement by setting threshold values of the chest and toe velocity, and then applied a systematic sampling procedure to sample 20 frames. According to four different sets of feature, we built four models, named Single\_Acc\_Model, Bi\_Acc\_Model, Single\_Pose\_Model and Bi\_Pose\_Model. Feature sets for Single\_Acc\_Model and Bi\_Acc\_Model are acceleration data, while those for Single\_Pose\_Model and Bi\_Pose\_Model are pose data. Data of feature sets for models with "Single" and "Bi" in the name is from the marker of the dominant hands wrist and two wrists, respectively. Each movement of Single\_Acc\_Model and Single\_Pose\_Model will yield 20 frames × one marker attached to the right wrist × 3(XYZ) = 60 features, Bi\_Acc\_Model and Bi\_Pose\_Model will have 60 × 2 = 120 features, the origin marker is excluded for Single\_Pose\_Model and Bi\_Pose\_Model. Models were trained and evaluated using support vector machine (10-Fold cross-validation approach).

**RESULTS:**

Bi\_Acc\_Model (accuracy=38%, F1-score=0.38) performed better than Single\_Acc\_Model (accuracy=33%, F1-score=0.31), but both showed quite low accuracy. Single\_Pose\_Model (accuracy=92%, F1-score=0.91) and Bi\_Pose\_Model (accuracy=92%, F1-score=0.92) outperformed both two models based on acceleration data. It showed that pose is more accurate for basketball movements recognition than acceleration. And the non-dominant hand has little significance for basketball movement recognition.

**CONCLUSION:**

Acceleration of the wrist of dominant hand failed to achieve high accuracy of basketball movement recognition, and the position of the wrist relative to the chest was found to be a better protocol.

**REFERENCE:**

- 1 Emily et al., 2018.
- 2 Tang et al., 2020.

## VALIDITY OF THE POLAR OH1 AND FITBIT CHARGE 3 DEVICES FOR MEASUREMENT OF HEART RATE DURING LIGHT, MODERATE, HEAVY AND SPRINT TYPE EXERCISE

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**INTRODUCTION:**

Accurate, continuous heart rate (HR) measurements are important for health, physical activity and sporting performance and the integration of HR to wearable devices has extended its accessibility. Optical HR sensors utilising photoplethysmography (PPG) technology are exciting because they avoid the requirement for chest strap/ electrocardiogram devices to be worn. Whilst the use of PPG technology is not new, the available data relating to the validity of measurement is limited. Furthermore, the range of activities being performed is often restricted to one exercise domain and/ or limited intensities. Therefore, the aim of the present study was to assess the validity of the Polar OH1 (OH1) and Fitbit Charge 3 (FB) devices for measuring HR during rest, cycling, walking and running activities across a range of intensities (light, moderate, heavy and sprinting).

**METHODS:**

Twenty healthy adults (9 females, Height: 1.72 ± 0.1 m, Body Mass: 71.0 ± 11.1 kg, Age: 41 ± 10 yrs) volunteered and provided written informed consent to participate in the study. The study consisted of two trials. Trial 1 (n=20) was split into 3 components: 1) 15 minutes sedentary/resting activities; 2) 10 min cycle on a bicycle ergometer; 3) Incremental exercise test to exhaustion on a motorised treadmill (18-42 min). Trial 2 (n=18) was split into 2 components: 1) 4 × 15s supramaximal sprints on a cycle ergometer; 2) 4 × 30-50 m sprints on a non-motorised resistance treadmill. Data from the three devices were time-aligned and validity of the OH1 and FB were assessed against the Polar H10 (H10; criterion device). Validity was evaluated using Pearson moment correlation coefficient, Bland and Altman analysis and the mean absolute percentage error (MAPE). Correlation coefficients were interpreted as very poor (r <0.69), poor (r = 0.70 to 0.84), good (r = 0.85 to 0.94), very good (r = 0.95 to 0.994) and excellent (r >0.995).

**RESULTS:**

Overall, there was a small mean bias and a very good correlation between the OH1 and the H10 device (bias = 1 bpm,  $r = 0.95$ ,  $P < 0.001$ ). However, the limits of agreement (LoA) were wide (-21, 24). The FB device underestimated HR by 8 bpm compared to the H10, with large LoA and poor correlation (-33, 49,  $r = 0.8$ ). The MAPE for both devices were deemed acceptable ( $< 5\%$ ). The OH1 performed well across each phase of trial 1, but validity was poor for trial 2 ( $r < 0.8$ ). The FB only performed well during rest and non-sprint-based treadmill activities (MAPE  $< 5\%$ ,  $r > 0.85$ ).

### CONCLUSION:

The key findings were that, compared with our criterion device, the OH1 was accurate at assessing HR but the accuracy of the FB was generally poor. The OH1 performed worse during trial 2 compared to the activities in trial 1 and validity of the FB device was particularly poor during cycling exercise versus H10.

### FUNDING:

This work has been funded by the EUs INTERREG VA programme, managed by the Special EU Programmes Body (SEUPB) and Highlands & Islands Enterprise (HMS 9353763).

## **THERMONET: AUTOMATIC SEGMENTATION OF BLOOD VESSEL PATTERNS DETECTED BY INFRARED THERMOGRAPHY DURING DYNAMIC EXERCISE**

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### INTRODUCTION:

In sports science the use of computer vision and machine learning (ML) approaches is steadily increasing. The application of ML allows an automated analysis of extensive data sets, which can be collected by diagnostic methods in different sports. Recently, it has been shown that infrared thermography (IRT) reveals different blood vessel patterns on the skin surface of extremities during different types of exercises [1]. Even though those observations are promising from a physiological perspective, currently there are some limitations regarding the analysis strategy [1]. For example, one IRT recording during an endurance exercise test results in 15.000 thermograms (10 min at 25 fps). At present, only a few thermograms are manually selected and analyzed with simple computer vision methods, which hampers the full analysis thermographic data. Therefore, we developed a new ML-based method to automatically analyze all 15.000 thermograms, which can be recorded during endurance exercise testing.

### METHODS:

Each thermal image (single channel) is analyzed pixelwise by a new introduced artificial neural network (ANN) based on U-Net [2]. This ANN segments each of three blood vessel patterns (0=no vessels; 1=venous vessels; 2=perforator vessels). For the training and validation of the ANN, we hand-labeled those patterns in 218 thermograms and additionally applied data augmentation (grid transformations, flipping, brightness change, random crop and Gaussian noise) to obtain a wider variety of our data set. Additionally, we conducted data set split (training/test) via distinct images as well as separation among test persons. Based on our segmentation, mean skin temperatures are calculated among all three pattern classes.

### RESULTS:

As a result the ANN allows the automated analysis of all thermograms of a sequence and produces graphs including data points with mean temperature values for each pattern type 0,1,2. The ANN achieves a Jaccard index (mIOU) of 63% for the test set of 42 images.

### CONCLUSION:

We demonstrate how ML approaches can improve the analysis of large amounts of IRT data in terms of objectivity and sensitivity. ANN automatically delivers more data than a manual analysis strategy. This extensive data set allows a more sensitive physiological interpretation of IRT data during endurance exercise testing. Additionally, this ML approach is time and cost saving and further enhances the practicability of IRT. Although the ANN performance can still be improved, the visual results are reasonable. Fine-tuning of the dataset labels and training algorithms with new labels from other exercises will further improve our model.

[1] Hillen et al.: Sports Med (2020)

[2] Ronneberger et al.: MICCAI (2015)

## **WEARABLE TECHNOLOGY FOR QUANTIFYING SLEEP AND AUTONOMIC FUNCTION: VALIDATION OF WHOOP**

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### INTRODUCTION:

Sleep, heart rate (HR) and HR variability (HRV) are important variables for inferring performance recovery and readiness to perform in athletes. This study evaluated the validity of WHOOP, a commercially available wrist-worn device that assesses sleep, HR and HRV via actigraphy and photoplethysmography.

### METHODS:

Sleep was measured via WHOOP and polysomnography (PSG) in 12 healthy adults ( $22.9 \pm 3.4$  yr) over 10 consecutive sleep opportunities in a sleep laboratory. For PSG, sleep recordings were scored by a single trained technician using standard criteria. For WHOOP, bed and wake times were entered into WHOOP's online platform and sleep episodes were scored using proprietary algorithms. 30-s epochs were compared between WHOOP and PSG for 2-stage (i.e. sleep, wake) and 4-stage (i.e. wake, light sleep, slow wave sleep [SWS], rapid eye movement sleep [REM]) categorisation via agreement, sensitivity, specificity and Cohen's kappa statistics. For HR and HRV, the last 5 min of the last light sleep episode, SWS episode and REM episode were identified using PSG-derived sleep staging data for each sleep opportunity, and time matched RR intervals were extracted from WHOOP- and electrocardiogram (ECG)-derived files. RR intervals were analysed using Kubios HRV software with WHOOP-derived intervals edited with "Low", "Medium", "Strong" and "Very Strong" filter strengths. HR and HRV (i.e. RMSSD and Ln RMSSD) were quantified for each filter strength and sleep stage. Agreement was assessed via bias, limits of agreement (LOA) and intra-class correlation (ICC).

### RESULTS:

In 2-stage sleep categorisation, the agreement, sensitivity to sleep, specificity for wake and Cohen's kappa were 89%, 95%, 51% and 0.49, respectively. In 4-stage sleep categorisation, the agreement, sensitivity to light sleep, SWS, REM and wake, and Cohen's kappa were 64%, 62%, 68%, 70%, 51% and 0.47, respectively. WHOOP-derived HR demonstrated acceptable agreement regardless of filter strength and sleep stage (bias as effect size (ES) with 95% confidence intervals  $\leq 0.09 \pm 0.11$ ;  $LOA \leq 5.13\%$ ;  $ICC \geq 0.98 \pm 0.01$ ). For HRV, a Strong filter (equivalent to a 200 ms editing threshold) resulted in best agreement across sleep stages (bias as  $ES \leq 0.12 \pm 0.18$ ;  $LOA \leq 39.73\%$ ;  $ICC \geq 0.91 \pm 0.06$ ). LOA

indicated better agreement for RR intervals analysed as Ln RMSSD ( $\leq 9.74\%$ ) compared to RMSSD ( $\geq 25.30\%$ ), and this agreement was not impacted by sleep stage since all measures of Ln RMSSD were within this parameters natural day-to-day variation ( $\sim 12\%$ ).

#### CONCLUSION:

WHOOP accurately measured 2-stage sleep categorisation, however sensitivity for detecting wake, light sleep, SWS and REM indicates scope for improvement. Nevertheless, WHOOP's performance is comparable to research-grade actigraphy-based sleep wearables, and may be a reasonable alternative when PSG is impractical. Acceptable agreement was found between WHOOP- and ECG-derived measures of HR and HRV when WHOOP-derived RR intervals were suitably edited to remove erroneous RR intervals and analysed as Ln RMSSD.

### MAGNITUDE-BASED DECISIONS HAVE A VALID BAYESIAN AND FREQUENTIST THEORETICAL BASIS

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#### INTRODUCTION:

Magnitude-based decisions (MBD) is an inferential method that avoids the problems of null-hypothesis significance testing by interpreting the frequentist compatibility interval and sampling distribution in terms of uncertainty in the true value of an effect. I show here that this reference-Bayesian interpretation is accurate. For statisticians who favor Popperian hypothesis testing, I show that MBD can also be formulated as one-sided interval hypothesis tests.

#### METHODS:

I devised a spreadsheet to perform Bayesian analyses with priors defined by normally distributed uncertainty. The hypothesis tests underlying MBD were established graphically.

#### RESULTS:

Realistic weakly informative priors that exclude extremely large magnitudes produce posterior distributions that are practically identical to the sampling distribution of the effect with the usual small (and any larger) sample sizes in sport and exercise research. In the clinical version of MBD, an effect has acceptable uncertainty and is considered potentially publishable and implementable in a clinical or practical setting when the true effect is most unlikely harmful and at least possibly beneficial. This requirement is equivalent to rejecting the hypothesis of a harmful effect ( $p_H < 0.005$ ) and failing to reject the hypothesis of a beneficial effect ( $p_B > 0.25$ ). In non-clinical MBD, an effect has acceptable uncertainty and publishability when the true effect is very unlikely to be substantial of one or other sign. This requirement is equivalent to rejecting one or other hypothesis of substantial magnitude ( $p_+ < 0.05$  or  $p_- < 0.05$ ). An unclear effect has unacceptable uncertainty and is equivalent to failure to reject both hypotheses; a minimum desirable sample size is estimated to avoid this outcome. In both forms of MBD, level of evidence for the magnitude of the true effect is expressed using the Bayesian terms possibly, likely, very likely and most likely; equivalent frequentist terms derived from additional hypothesis tests of non-substantiveness and non-triviality are respectively ambiguously, weakly, moderately and strongly compatible with the magnitude.

#### CONCLUSION:

The error rates associated with the hypothesis tests correspond to those originally defined and quantified in MBD, which were shown by simulation to be generally lower than those of null-hypothesis testing with 80% power for 5% significance. To reduce misinterpretation of outcomes, clear, decisive or conclusive should be reserved for effects with acceptable uncertainty that are very likely or most likely substantial or trivial (moderately or strongly compatible with substantial or trivial). In conclusion, researchers can make magnitude-based decisions, confident that the decisions have a sound Bayesian or frequentist theoretical basis and acceptable inferential properties with the current probability decision thresholds.

### A NOVEL APPROACH FOR SWIMMING ANALYSIS IN MAIN SWIMMING STYLES USING A SINGLE SACRUM-WORN IMU SENSOR

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#### INTRODUCTION:

Today, inertial measurement units (IMU) provide promising solutions for swimmers' motions analysis [1-3]. However, most studies focused on a few parameters, often during strokes of front crawl style [4]. For swimming training session monitoring, there is a need for automatic detection of swimming and lap periods, styles and more details within each lap. This study proposes a general approach starting with macro-level analysis to detect swimming bouts, laps, and styles, going to micro-level analysis related to specific phases of swimming.

#### METHODS:

17 professional swimmers performed four 50-m trials in main swimming styles, i.e. front crawl (FC), backstroke (BaS), breaststroke (BrS) and butterfly (BF), in a 25-m indoor pool. Acceleration and angular velocity were recorded at 500 Hz sampling rate with a single sacrum-worn waterproofed inertial sensor (Physilog® IV, Gait Up, CH). Five cameras (GoPro Hero 7 Black, GoPro Inc., US) were used for validation. In macro-analysis, swimming bouts were recognized from rest periods through sharp changes on sacrum inferior-superior acceleration and its derivative. Within each bout, peaks of sacrum anteroposterior (A/P) acceleration were used to mark turns for separating laps. FC and BaS styles were classified from the dominant angular velocity, identified by principal component analysis (PCA) and gravity direction. Frequency analysis of A/P acceleration was used for differentiating between BrS and BF. In the micro-level analysis, based on peak detection, zero-crossing, thresholding and PCA different swimming phases were detected as: wall push-off, glide, strokes preparation, strokes and turn.

#### RESULTS:

Swimming bouts were detected with 97.5% accuracy, 99.4% sensitivity, and 99.8% precision. All turns have been detected correctly. FC and BaS styles were identified with no error, while the accuracy, sensitivity, and precision reached respectively 97.2%, 97.2% and 97.9% for BrS, and 97.9%, 97.9% and 97.2% for BF. Finally, errors (in ms) for the onset of each phase were:  $-20 \pm 89$  (wall push-off),  $5 \pm 100$  (glide),  $-31 \pm 105$  (strokes preparation),  $28 \pm 205$  (strokes),  $24 \pm 97$  (turn),  $-2 \pm 65$  (next wall push-off).

#### CONCLUSION:

By automatic assessment of swimming and rest bouts, laps number and duration, swimming styles as well as swimming phases within each lap using a single sacrum-worn IMU, this study offers coaches and swimmers an easy to use tool for monitoring swimming training sessions. Compared to other studies [5-6], style identification reached better accuracy. While the performance of the system for phase detection is acceptable, it can be improved by adding IMU sensors to other body locations.

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### COMPARISON OF SUB-TECHNIQUE UTILIZATION, KINEMATICS AND PHYSIOLOGICAL RESPONSES BETWEEN LOW- AND HIGH-INTENSITY ROLLER SKI SKATING

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#### INTRODUCTION:

Cross-country (XC) skiers continuously shift between various sub-techniques according to track topography, speed and environmental conditions. When using the skating style, skiers mainly transition between three gears; gear2 (G2) on uphill terrain, gear3 (G3) on uphill and flat terrain, and gear4 (G4) on flat terrain. The main aim of the study was to compare the proportional use of sub-techniques and related kinematical and physiological data between low- and high-intensity roller ski on a simulated competition profile.

#### METHODS:

13 elite male skiers and biathletes (peak oxygen uptake (VO<sub>2</sub>) 70±4 mL·kg<sup>-1</sup>·min<sup>-1</sup>), participated in the study. The protocol consisted of two 7x3-min bouts on a treadmill across a simulated lap profile with set inclines, performed at low and high speed, corresponding to low (LIT) and high (competition) intensity (HIT). The HIT bout was immediately followed by an incremental all-out test (AOT) to simulate a mass start finish. Kinematics, speed, incline, cardiorespiratory variables and pole forces were measured continuously. Automatic cycle detection were based on accelerometer data and together with speed used to determine cycle rate (CR) and cycle length (CL). A machine learning algorithm was developed to automatically classify each cycle to a sub-technique using sensor data. Four of the skiers did not manage to complete the HIT bout at the set speeds and inclines and were excluded from the analysis.

#### RESULTS:

The average power output during LIT and HIT was 203±37W and 283±93W, while the skiers finished the AOT at 372±44 W. Also heart rate (HR) and VO<sub>2</sub> increased for HIT compared to LIT, but fluctuated within each 3-min lap according to the terrain; increased uphill and reduced flat/downhill. Average values for HR were: LIT: 71±10 % vs HIT: 86±12% vs max AOT: 100% of maximal HR, average values for VO<sub>2</sub> were: LIT 60±15 vs HIT 81±18 and max VO<sub>2</sub> at AOT 100 % VO<sub>2</sub>). In HIT compared to LIT, an increase in the utilization of G3 and a corresponding decrease in the utilization of G2 was observed while G4 was unchanged (LIT/HIT: G2 23%/6%, G3 43%/60%, G4 34% both). For AOT mainly G3 was utilized (98%, remainder G2). CR and CL increased with higher speed from LIT to HIT (CR LIT/HIT/AOT: G2 0.72±0.05/0.92±0.06/NAHz, G3: 0.48±0.04/0.52±0.05/0.55±0.05Hz, G4: 0.63±0.03/0.66±0.03/0.66±0.03Hz) (CL LIT/HIT/AOT: G2 3.2±0.5/4.3±0.05/NA m, G3 9.0±1.6m/11.4±1.1m/11.4±1.1m, G4 8.9±1.2m/10.2±1.2/8.6±0.5m).

#### CONCLUSION:

This study explored sub-technique utilization, kinematics and physiological responses in XC skiing. The distribution of sub-techniques changed with increasing speed at unaltered incline from LIT to HIT, with more G3 and less G2 employed at higher speed during HIT, which is in line with the observed speed thresholds between sub-techniques observed in classical XC-skiing. Correspondingly, average CR and CL within all sub-techniques increased from LIT to HIT. While HR and VO<sub>2</sub> remained similar across laps during LIT, a HR-drift from lap-to-lap was observed during HIT.

### A NOVEL RESEARCH METHOD USING ARTIFICIAL INTELLIGENCE IN SPORT SCIENCE: USING MACHINE LEARNING TO PREDICT CHANGES IN COUNTERMOVEMENT JUMP PERFORMANCE BEFORE AND AFTER TRAINING AS SUPER META-ANALYSIS

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#### INTRODUCTION:

Meta-analysis (MA) is conducted via combining data from smaller studies that leads to greater statistical power and more robust answers to research questions. In sports science, a conventional MA can show the magnitude of effects from specific physical training method for a given population, but cannot necessarily predict the training effects of individuals with different backgrounds or training contexts. Whereas, machine learning (ML) a proven artificial intelligence technique can make accurate classifications or numerical predictions. This study aimed to predict the performance changes in countermovement jump (CMJ) height using ensemble ML algorithm and data provided from current MA studies.

#### METHODS:

A total of 59 studies including 140 groups (or conditions) of subjects from 7 recent MAs were included. CMJ difference between pre- and post-test for each subject group was calculated. Upsampling of data was performed according to the sample size of each subject group and total 1753 observations were contained in the dataset. Features including; age, gender, race, athlete type, number of training sessions, mode of training, inclusion of specific lower limb strengthening exercises, periodization or intraset rest techniques, volume per session and baseline CMJ values were selected for ML purpose while the outcome variable was CMJ differences (in cm). Random forest (RF) (max\_depth=12, n\_estimators=40, min\_samples\_leaf = 1, min\_samples\_split = 2, random\_state = 0) with k-fold cross validation (n\_splits = 4 and 20% as testing data) was applied in Python (version 3.7.4) using Jupyter notebook and scikit-learn. Mean absolute error (MAE) of training and testing datasets were compared to evaluate model performance and judge any existence of underfitting or overfitting issue.

#### RESULTS:

Extremely high model accuracy was yielded [MAE of training set: 0.023; MAE of testing set: 0.027] with very slight overfitting issue observed. The top six important features and its arbitrary score of importance identified in RF included "inclusion of plyometric training (mixed with fast and slow stretch-shortening cycle), 0.195", "baseline CMJ values, 0.169", "total volume per session = none, 0.154", "age, 0.152", "inclusion of specific lower limb strengthening exercises: squat, lunge, deadlift and hip thrust = false, 0.051", and "type of athlete = jumping sport related, 0.048"

#### CONCLUSION:

Using existing published data from MAs with ensemble ML such as RF can predict changes in CMJ performance difference with very high accuracy. The model can use learned data to predict changes in CMJ for most unseen subjects. Therefore, ML can potentially upscale conventional MAs to super meta-analysis, performing predictive analytics and bridging gaps of current published literature. Challenges in using this novel research method include potential factors that may produce bias or inaccurate results, in which the model must be carefully investigated and modified for future use.

## OP-AP15 Individual sports

### ANALYZING THE STRENGTH AND CARDIOVASCULAR PARAMETERS IN ARTISTIC SWIMMING PERFORMANCE

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#### INTRODUCTION:

Artistic swimming is more than just a sport. High level of technical knowledge, conditional abilities and collaborating with teammates are necessary for the appropriate performance. The complexity of this sport comes from 75% of water exercises and 25% of various land training. The aim of our study was (i) to measure the relationship between the technical elements and strength parameters in artistic swimming. Furthermore (ii) to investigate the relationship between the duet, team, combination routines of artistic swimming and the cardiovascular changes during performance.

#### METHODS:

Hungarian junior synchronized swimmers participated in the study (Study1: N1=32, 13.65±1.1yrs, training years: 5.4±2yrs, training time was 4x3hrs/week; Study2: N2=48, 17.44±2.83yrs, training years: 5.83±1.58yrs, training time was 5x3hrs/week).

Maximal handgrip strength was measured with a dynamometer and vertical jump height of athletes was measured with a forceplate. Heart rate (HR) and blood lactate level (BL) were also analyzed in rest and after 1 minute of exercise (swimming, artistic swimming routines), respectively. 3 basic elements in artistic swimming (body boost, vertical position, barracuda) were performed by the athletes and scored by judges. Artistic swimming and swimming performances were measured twice a years. Statistical analyses: Dependent sampled T-test, ANOVA, Post Hoc Test Correlations, Spearmans rank correlation.

#### RESULTS:

Positive correlation was found ( $r=0.62$ ,  $p<0,05$ ) between maximal handgrip strength ( $25.10\pm3.22\text{kg}$ ) and barracuda scores ( $6.10\pm0.59$ ), and stronger correlation ( $r=0.72$ ) with vertical position ( $5.83\pm0.6$ ). Body boost ( $7.46\pm0.34$ ) and vertical jump ( $22.13\pm2.67\text{ns/kg}$ ) are significantly correlated ( $r=0.67$ ). The mean HR was  $169\pm16.3\text{bpm}$  in combination,  $161.80\pm13.97\text{bpm}$  in team,  $149.6\pm15.66\text{bpm}$  in duet,  $145.5\pm16.12\text{bpm}$  in team. The blood lactate was also measured (combination:  $9.97\pm2.24\text{mmol/l}$ , team:  $11.11\pm3.13\text{mmol/l}$ ; duet:  $11.42\pm2.82\text{mmol/l}$ ; swimming:  $12.08\pm3.24\text{mmol/l}$ ). The highest values in peak heart rate (178 bpm) and blood lactate ( $16.1\text{mmol/l}$ ) were registered in team routines. No significant difference was found in the change of BL and the HR either after artistic swimming routines and swimming.

#### CONCLUSION:

Strong correlation was found between the performance of basic synchro elements and muscle strength. Higher maximum BL, lower HR was founded compared to the earlier research (Rodríguez et al. 2014). Correlation was founded between the strenght and the artistic swimming elements, respectively between swimming efficiency affects and the performance of different technical elements.

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### EFFECT OF INSTRUCTIONS ON ATTACK EFFICIENCY IN BEGINNERS AND EXPERIENCED FENCERS

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#### INTRODUCTION:

The success in any combat sport depends remarkably on attack efficiency. In order to be efficient, an attack should be performed not only as accurately as possible, but also with the minimum reaction time and maximum movement speed. On the other hand, an internal or external attentional focus during the action proved to be the relevant factor when movement efficiency has to be considered. Specifically, the experienced individuals benefit from an external focus of attention, whereas the beginners benefit from an internal focus of attention [1]. Therefore, we designed the study aimed to investigate the effects of different instructions on attack efficiency in fencers of different level of expertise. It was hypothesized that the beginners and experienced fencers will benefit mostly from the internal and external focusing instructions, respectively.

#### METHODS:

Ten beginners and 10 experienced fencers participated in the study. A video-based method [2] was used to present two typical fencing movement techniques (i.e. "stimulus") after which the participants had to perform an offensive (high or low attack) action (i.e. "response"). Three different instructions were used in order to direct the attentional focus: (1) to react as fast as possible; (2) to perform the attacking movement as fast as possible; (3) to be accurate as much as possible. The index of attack efficiency has been calculated based on the results of reaction time, movement speed and absolute error relevant to the previously designated target.

#### RESULTS:

The different effects of instructions on movement performance have been shown in both groups of subjects, specifically, when the level of movement accuracy was compared to either reaction time or movement speed ( $p < 0.05$ ). Moreover, the movement performance as assessed through any of three selected parameters (i.e., reaction time, movement speed and movement accuracy) was significantly better in experienced fencers than in beginners ( $p < 0.05$ ). Finally, the index of attack efficiency was significantly higher in experienced fencers as well as beginners when the subjects were instructed to react as fast as possible ( $p < 0.01$ ). The instruction to be accurate as much as possible provided the lowest index of attack efficiency in beginners ( $p < 0.01$ ).

#### CONCLUSION:



The instruction to be accurate as much as possible directs the attentional focus to external stimuli that proved to be detrimental for beginners. This effect was not as prominent in experienced fencers which could be in line with the proposed hypothesis. Anyway, the instruction to react as fast as possible seems to provide the most efficient attack in fencing despite the level of expertise. One could speculate that this instruction is partly based on both internal and external attentional focuses suggesting that the complex situations in combat sports requires partly divided attentional focus rather than strictly directed.

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2) Mudric et al., *Int J Perform Anal Sport*, 2015

## **ARTISTIC GYMNASTICS IMPROVES HEALTH-RELATED BIOMARKERS AT PRIMARY SCHOOL AGE**

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*STK SPORT*

### **INTRODUCTION:**

Artistic gymnastics requires the performance of a variety of technical elements on different apparatuses where gymnasts have to overcome their body mass and even multiply it by several times when tumbling and dismounting (Jemni 2018). Maintaining optimal health and a good level of physical fitness is crucial in order to successfully perform the routines. The aim of this study was to assess health-related biomarkers to physical fitness in young gymnasts whilst estimating the benefits of regular gymnastics practice at primary school ages.

### **METHODS:**

The study included 49 children (mean age of 9.5 years) who were practising artistic gymnastics for at least 2 years with an average of 6 hours per week, and a control group of 41 children (mean age of 8.9 years). The participants completed the Alpha-Fit physical fitness test battery (BMI, %BF, handgrip strength, standing long jump, 4x10m shuttle run test and 20m multistage fitness test). Body fat percent (%BF) was assessed by the Tanita BF-689, and VO<sub>2</sub>max was estimated from the 20m shuttle test by applying the BeepShuttle Junior software (Kolimechkov 2018) using Leger's equations for children. Percentile scores for the results from the different tests were calculated.

### **RESULTS:**

The scores of the main anthropometric variables, including height, body mass, BMI, and %BF in the male and female gymnasts were significantly lower than those of the control groups ( $p < 0.001$ , with very large effect size  $d > 1.20$ ). All gymnasts had their body fat within the norms. There were no significant differences between the handgrip strength of the gymnasts and the control group for both genders. However, when reported to the relative arms area, gymnasts showed significantly higher relative upper arm muscle area and relative handgrip strength in comparison to the control groups (0.58 kg/kg body mass vs 0.42 kg/kg body mass in boys,  $p < 0.001$ ,  $d = 2.00$ , and 0.52 kg/kg body mass vs 0.45 kg/kg body mass in girls,  $p < 0.01$ ,  $d = 0.78$ , respectively). The results from the standing long jump test, 4x10m shuttle run test, as well as the 20m shuttle run test, were significantly greater in favour of the gymnasts in comparison to the control groups for both genders ( $p < 0.001$ ,  $d > 1.20$ ).

### **CONCLUSION:**

These findings show that gymnastics training in childhood, contributes to maintaining a normal mass, and thereby sustaining a normal health status. Practising artistic gymnastics has a positive impact on the health-related biomarkers of children's physical fitness.

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## **TIME-MOTION ANALYSIS OF THE MOST PERFORMED KATAS AT THE TOP-LEVEL KARATE COMPETITION**

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### **INTRODUCTION:**

With OG 2020 approaching, flag system changed to scoring system to ensure objectivity. There are 102 katas in the official list. Seven judges evaluate athletic and technical performance, whilst 2 highest and 2 lowest scores are excluded (total score – TS). However, katas are not divided according to length or the number of techniques of various levels of difficulty and energy demandingness. There are several studies dealing with physiology response, nevertheless load content is not clear. The aim of the study is to identify the frequency of techniques (no. of movements per sec) expressed in hertz, ratio of slow and fast techniques and their affinity to judges' TS of the most popular kata performed at top-level karate competitions.

### **METHODS:**

We analysed the recording of 5 most frequently performed katas[1] executed by world champions of Karate 1 Premiere League (Anan, Chatanyara Kushanku, Suparinpai, Gojushiho Sho, Unsu). LongoMatch software and specially developed high reliability template ( $K > 0.91$ ) was used for the video analysis. The performance indicators included fast and slow transitions, stance height, lower limb techniques and fast and slow upper limb techniques. Data were subjected to Chi-square and descriptive statistics.

### **RESULTS:**

There is a significant relationship between performed katas and frequency (distribution) of techniques  $\chi^2$  (20, N = 778) = 54.92,  $p = .00$ . Techniques were performed as follows: Anan 154 techniques in 131 seconds (1.18 movements/s) - 86 fast and 29 slow - 2.97 ratio (TS 23.64); Chatanyara Kushanku 192 tech. in 152 s (1.26 movm./s) - 117 fast and 19 slow - 6.16 ratio (TS 23.78); Gohushiho Sho 136 tech. in 151 s (0.9 movm./s) - 70 fast and 32 slow - 2.19 ratio (TS 22.99); Suparinpai 189 tech. in 203 s (0.93 movm./s) - 78 fast and 66 slow - 1.18 ratio (TS 23.09); Unsu 107 tech. in 149 s (0.72 movm./s), 52/20 2.6 (TS 23.06). Total score[2] indicates that katas with higher slow to fast movement ratio (the ones with more movements and higher frequency of movements) receive higher score from the judges as apparent from results such as in Chatanyara Kushanku.

### **CONCLUSION:**

The results show that katas have different content (number of punches, stances, kicks etc.), different duration, and ratio of fast and slow techniques. These indicators affect the load intensity and so the physiological response of the athlete. Therefore, the rest of the kata should be subjected to time-motion analysis so they can be divided into age-appropriate categories or competition rounds based on technical and energetical demandingness. Practicing at lower speed and lower frequency as well as including all 102 katas in training in the

younger categories helps to avoid problems of premature specialization and ensures exercise at a higher quality level in long-term athlete development.

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2. Augustovicova et al. The issue... *Archives of Budo* 2019;15:241–8.

VEGA No. 1/0654/19

### **A STUDY OF SLING EXERCISE TRAINING FOR JUDO ATHLETE TO IMPROVE THE TECHNIQUE OF SEOI-NAGE**

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#### **INTRODUCTION:**

As an important and the most frequently used Judo skill, the technique of Seoi-nage requires Judo athlete to disturb the balance of the opponent, and maintain his own stability and balance at the same time. This lies on the strong support in core muscles. As we know, sling exercise training (SET) is an effective method for core stability training, which can enhance core strength and stability and improve the ability of balance control. However, very few studies are found about application of SET in the Judo training. The purpose of the study is to investigate how SET affects the technique of Seoi-nage for Judo athletes.

#### **METHODS:**

The subjects are male Judo athletes from a sports university. Those athletes with injury, who are not available for training, are excluded by questionnaire. At last, 14 male athletes, who are all athletes of National Rank 2, participated in this study. These 14 athletes were randomly divided into two groups, the SET group (S, n=7) and the control group (C, n=7). The group S used the SET program particularly designed for them, while the group C had only conventional free-hand training, which had the similar load as the group S. They took the training for a total of 6w, three times per week, and each time last 15-20 minutes. Before and after the training, movement of Seoi-nage are recorded and analyzed by the video analytical system. The kinematical parameters include the level of the trunk flexion angle, angular velocity and the leg speed. The data are processed by SPSS 13.0. Single factor analysis of variance is used. The significant difference is at 5% level.

#### **RESULTS:**

After 6w-training, compared to group C, group S had significant increases in (1) the trunk flexion angle ( $28.39 \pm 13.75$  vs  $20.11 \pm 6.34$ o,  $P < 0.05$ ) and angular velocity ( $197.00 \pm 18.75$  vs  $177.10 \pm 15.39$  degrees/sec,  $P < 0.05$ ), and (2) the speed of leg in the stage of entering ( $0.12 \pm 0.02$  vs  $0.15 \pm 0.04$  sec,  $P < 0.05$ ) and action completion time ( $0.60 \pm 0.12$  vs  $0.65 \pm 0.04$  sec,  $P < 0.05$ ).

#### **CONCLUSION:**

6w- SET can improve the technique of Seoi-nage for male Judo athletes. It seems that SET is more efficient than conventional free-hand training for Judo's specialized training.

### **IMPROVEMENTS IN VISUOMOTOR REACTION SPEED FOLLOWING A 10-WEEK STROBOSCOPIC TRAINING IN ELITE YOUNG BADMINTON PLAYERS**

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#### **INTRODUCTION:**

Visuomotor abilities and especially the speed of visuomotor reactions play a performance determining role in numerous ball and team sports. Accordingly, previous research evaluated the specific training of visual/visuomotor abilities by applying visual training interventions such as stroboscopic training. However, although the results were promising, these studies were limited either by small samples or the inclusion of untrained participants. Therefore, this study examined the effectiveness of stroboscopic training in a larger group of highly trained badminton players.

#### **METHODS:**

34 elite German youth badminton players (mean age: 14.4 years) participated in this study. For a training period of 10 weeks, athletes were assigned to an intervention or control group, training under stroboscopic or normal visual conditions, respectively. Stroboscopic eyewear was used during regular badminton training tasks including drive and net combinations as well as smash defense exercises. The number and duration of sessions per week were standardized and identical for both groups. The training intervention was followed by a 6-week retention period. The visuomotor reaction speed prior to and after the training as well as following the retention interval was determined in response to slow (5 Hz) and fast (20 Hz) visual motion stimuli presented on a computer screen. Statistical comparisons were performed using a repeated measures ANOVA with the within-subject factors "CONDITION (5 Hz, 20 Hz)" and "TIME" (pre, post, retention) as well as the between-subject factor "GROUP" (intervention, control).

#### **RESULTS:**

The ANOVA revealed a significant main effect for "CONDITION" ( $p < 0.001$ ,  $\eta^2 = 0.95$ ) indicating faster visuomotor reactions in response to fast (20 Hz) when compared to slow (5 Hz) visual stimuli as well as a GROUP X TIME interaction ( $p = 0.027$ ,  $\eta^2 = 0.11$ ). For the intervention group, post-hoc tests revealed a significant acceleration of the reaction time from the pre to the post test ( $p = 0.045$ ) while the difference between the pre- and the retention-test did not reach the significance level ( $p = 0.075$ ). In contrast, for the control group there was no change in reaction speed over time (pre-post:  $p = 0.255$ , pre-retention:  $0.933$ ).

#### **CONCLUSION:**

The results support the effectiveness of stroboscopic training to improve the speed of visuomotor reactions in already highly trained athletes. Moreover, the study suggests the applicability of stroboscopic eyewear in regular training thus avoiding extra training time that is limited especially on a high performance level. These findings may be of special interest for athletes and coaches participating in visuomotor demanding disciplines. Future research will evaluate the transferability of performance improvements to real game situations and investigate potential adaptations on the visual and motor level contributing to the observed behavioral effects.

## OP-AP16 Coaching

### PATHWAYS TO EXCELLENCE IN ALPINE SKIING

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#### INTRODUCTION:

To achieve expertise in sport, extensive engagement in sport-specific practice activities is needed. The amount of time spent in practice and the nature of practice activities engaged in throughout development can impact performance level. The developmental history profiles needed to reach elite status in alpine skiing have yet to be examined empirically; the pathway may require unique engagement in practice activities that reflect the challenging environmental conditions, seasonal training constraints, and elevated injury risk/physical demands. Also, cultural variance may modulate engagement in alpine skiing due to different funding and training structures.

#### METHODS:

We review findings from a programme of research examining associations between developmental trajectories, engagement activities, and performance of alpine ski racers from academies based in the United States (N = 169) and Austria (N = 209). Practice history profiles and national technical (i.e., slalom) and speed (i.e., downhill) points were used to assess engagement in practice activities and performance, respectively.

#### RESULTS:

Hierarchical linear models revealed that performance improved and hours of practice increased over time, with more time spent in ski-specific practice associated with faster improvement rates. For both disciplines, more hours in structured activity (i.e., coach-led group practice) was positively associated with improved ranking for younger ski racers and hours in unstructured activity (i.e., play) decreased over time ( $p$ 's < .24). In the U.S., ski racers performed better in speed events, which may be reflective of greater engagement and competition in this discipline throughout development, whereas technical ski racers in Austria tended to follow a specialization pathway, engaging at an earlier age in skiing and in competition, while taking part in fewer other sports. Ultimately, in Austria ski racers performed better in 2019 technical events compared to those based in the U.S. ( $p$ 's < .001).

#### CONCLUSION:

Although U.S. based racers accumulated more practice hours than those in Austria, this was not reflected by superior performance. Cultural factors impact the efficiency and rigor of training, with U.S. academies taking a more diverse approach, engaging in other sports, and cross-disciplinary training compared to Austrian academies. Overall, ski racers specialize early, acquiring a high volume of ski practice hours, in tandem with engaging in multiple other sports throughout development. Our findings speak to the distinct nature of alpine skiing, highlighting that developmental trajectories more closely reflect a continuum between specialization and diversification pathways. Cultural variance provides insight into the benefits of quality training over quantity. In future, researchers should evaluate the macro-structures of coaching sessions across different countries to provide greater insight into the type of practice most likely to benefit performance.

### EXPLORING THE EFFECT OF VARIOUS MATCH FACTORS ON TEAM PLAYING STYLES IN THE NATIONAL RUGBY LEAGUE

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#### INTRODUCTION:

Rugby league (RL) is a complex team sport, requiring the continual strategic (re)organisation of players in response to a range of constantly changing and interacting match-constraints [1-4]. In an attempt to manage this complexity, it is common for teams to develop specific playing patterns in certain phases of the game [4]. Whilst these behaviours typically aim to promote adaptable and flexible playing patterns [4,5], team tendencies (playing styles) may still be observable across the various phases of game-play (i.e., attack, transition or defence). Resolution of these playing styles could lead to a performance advantage in practice. As such, work in RL has explored the changes in team playing styles over seasons in both the National Rugby League (NRL) and European Super League [6,7]. This study extends upon this prior work by examining the effect of match location, score-line, team quality (measured as end of season (EOS) rank) and match outcome on team playing styles in the NRL.

#### METHODS:

Thirty-eight performance indicators (e.g. offloads, runs...) from all NRL games during the 2015-2019 seasons (n=2,010) were collected. The match-related variables examined were location (home/away/neutral), score-line (absolute score differential), team quality (EOS ladder position) and outcome (win/draw/loss). Factor analysis using the principal component analysis (PCA) model allowed to identify team playing styles, which were inferred from the clustered dimensions (Factors) of team performance indicators. Discriminant analysis was then used to determine the effect of the match-related variables on team playing styles.

#### RESULTS:

The PCA revealed nine Factors accounting for ~54% of team performance variance. Discriminant analysis did not meaningfully resolve team playing styles for score-line, team quality or location (~34%, ~46% and ~58% classification accuracy, respectively). One discriminant function successfully classified ~81% of matches based on outcome, including four team playing styles defined as 'attacking play', 'linebreaks', 'handling errors' and 'conceded linebreaks'.

#### CONCLUSION:

Team playing styles characterised by 'attacking play' and 'linebreaks', coupled with relative defensive efficiency (shown via reduced 'conceded linebreaks'), exhibited the greatest association with winning regardless of team quality, match location or score line. In contrast to prior research, our study did not meaningfully resolve team playing styles for the remaining match factors. Using similar sport analytical techniques, additional insight into the importance of various team playing styles over the time-course of a match may allow teams to further extrapolate the likelihood of success in real-time.

1. Memmert et al. (2017) 2. Lago-Peñas et al. (2018) 3. Woods et al. (2018) 4. Ribeiro et al. (2019) 5. Mckay & O'Connor (2018) 6. Wedding et al. (Under Review) 7. Parmar et al. (2018)

**IMPROVE THE BEST, DON'T WORRY ABOUT THE REST. AN INVESTIGATION OF ONE TEAM AND THEIR USE OF PERFORMANCE ANALYSIS AT HALF-TIME.**

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**INTRODUCTION:**

The weekly use of video and computer technology in elite soccer environments to evaluate performance has led to the acceptance by many coaches and players that performance analysis (PA) is a fundamental part of the feedback process. Within a match, half-time feedback allows the most direct route for PA to aid a coach's communication and decision making. As such this study aimed to ascertain the role that can be played by PA at half-time as well as investigating the way in which a coach's half-time feedback was altered with the availability of PA.

**METHODS:**

A mixed method approach was adopted in this research. One Under 15 academy team was selected to participate in the study which was structured in the following manner; Semi-structured interviews, half-time audio recording of six matches, intervention to develop half-time feedback process with PA, half-time audio recording of six matches, semi structured interviews. Participants were players (n - six), Head of Coach Development, Head Coach, Assistant Coach, Performance Analyst. Thematic analysis was carried out on the interview transcripts and half-time team talks.

**RESULTS:**

Thematic analysis generated three higher order themes and six lower order themes. The higher order themes were Analysis arms race, Performance takes precedence and Developing insight. The first higher order theme scrutinises the eagerness shown to engage in PA support with little knowledge of how or why this was to be done. The second higher order theme examines the complexities of how PA was used to support the development of winning football matches and to develop the very best players. Finally, the third theme discusses the way PA was used as source of insight into players performance and development even though this information was not always fed back to the players.

**CONCLUSION:**

Half-time team talks both with and without access to PA were used to support the development of a winning team. By focusing on providing information on tactical changes and appraising performance the coach aimed to increase the chance of winning the match. Interestingly, PA was not necessarily used to support the development of all players in a squad, but instead was specifically used to develop the players identified as the best. As such, within soccer coaching there is an eagerness to utilise any aspect of performance support that can aid a coach in their role however this is done with little thought of how or why this should be done.

**EFFECT OF A VIDEO EXPECTANCY MODIFICATION ON ENDURANCE AND EXPLOSIVE POWER PERFORMANCE – A PILOT STUDY**

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**INTRODUCTION:**

Placebo effects are outcomes resulting from a person's expectations to a treatment or substance [1]. Substances studied in the context of sport performance usually have a physiological ergogenic effect [2]. Less is known on placebo effects of substances in which a physiological ergogenic effect is absent and an expectancy modification might be harder to achieve. Therefore, the aim of the present study was to assess effects of an expectancy modification prior to water intake on endurance and explosive power performance.

**METHODS:**

Twenty-six healthy, moderately trained men (age: 23.9±3.1 years) were randomly assigned to the expectancy modification group (EG) or control group (CG) stratified by maximal oxygen uptake assessed in a baseline spiroergometry (50.8±4.8 ml/kg/min). Endurance performance was tested using a time trial to exhaustion with 110% of baseline performance. Explosive power was assessed using counter movement jump height. Prior to the tests, all participants drank 2x200 ml tap water. Before drinking the water, participants in the EG watched a one-minute expectancy modification video clip ensuring that the water will support the participants in showing the best performance. The video clip was not shown in the CG. Factorial ANOVA (EG, CG) and ANCOVA with baseline maximal oxygen uptake as covariate were used to analyze differences between EG and CG.

**RESULTS:**

Time to exhaustion was significantly longer in the EG (78.5±21.9 s) compared to the CG (53.9±20.1 s),  $F(1, 24) = 8.86$ ,  $p = .007$ ,  $d = 1.17$ . The difference remained significant when controlling for baseline endurance performance using an ANCOVA,  $F(1, 23) = 8.44$ ,  $p = .008$ . The counter movement jump height was not significantly different between EG (37.9±3.3 cm) and CG (37.5±5.3 cm),  $F(1, 24) = 1.23$ ,  $p = .805$ ,  $d = 0.10$ .

**CONCLUSION:**

The short video clip used in the present study aiming to modulate the expectancies of the participants resulted in a higher endurance performance also when a physiological ergogenic effect of the substance (water) is absent. Relatively large effect sizes compared to previous findings, e.g. [3], might be explained by the between-subject design of the present study. The role of expectancies on explosive power was less relevant in the present study. The finding underlines the importance of placebo effects in endurance performance and might be used by coaches [4].

1. Beedie et al. (2018) 2. Beedie & Foad (2009) 3. Hurst et al. (2019) 4. Szabo & Müller (2016)

**USING SOCIAL NETWORK ANALYSIS TO EVALUATE THE PERFORMANCE OF TEAMS IN CHINESE FOOTBALL ASSOCIATION SUPER LEAGUE**

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BEIJING SPORT UNIVERSITY

**INTRODUCTION:**

Social Network Analysis (SNA) can be used to investigate the functionality and efficiency of a group [1], which has been applied widely to analyze the correlation between network measures and performance outcomes in football. But so far, this method has not been used

much in studies of Chinese football matches. The aim of the study was to explore whether the macro-level network characteristics would show difference among teams with different outcomes (win, lose, draw) in Chinese Football Association Super League (CSL).

### METHODS:

Passing data from each match in the 2017-2018 CSL season (a total of 16 teams and 240 matches) were analyzed using SNA to establish 480 passing networks. A total of four network measures, including clustering coefficient, network density, average path length and total links, were calculated for each team from every match with Python's NetworkX. After testing the normality of the data, we ran one-way ANOVA and post-hoc tests to identify significant different pairs among winning, drawing and losing teams.

### RESULTS:

The descriptive statistics are as follows: clustering coefficient(win:0.70±0.07,draw:0.68±0.08,lost: 0.69±0.06), network density (win:0.55±0.08,draw:0.56±0.08,lost: 0.56±0.06),average path length(win:1.41±0.11,draw:1.39±0.11,lost: 1.41±0.10), and total links(win:90±14,draw:90±12,lost: 97±11).We found that only the total links(P<0.0001) showed significant differences under the three competition results. Next, the post-hoc comparison told us that there were significant differences in total links between winning and losing teams (P<0.0001) and between drawing and losing teams (P<0.001). The differences in both pairs yielded large effect size (d=-0.502 for win vs. lost; d=-0.544 for draw vs. lost). The network analysis of knockout phase of FIFA World Cup 2018 revealed that teams do not change macrostructures according to match status (i.e., losing, drawing, or winning) [2]. But in CSL, teams in the losing statuses have greater total links than the teams in the other two match statuses. This indicated that the high number of passes does not contribute much but somehow hinder to winning in CSL.

### CONCLUSION:

Under the premise of maintaining the overall strength level of the team, the coaches should train the team members to establish a compact and effective passing network instead of a structure with as many passes as possible. This study provided insights into the training and performance evaluation of CSL teams.

1 Kothari, et al. (2014)

2 Gibson Moreira Praça, et al. (2019)

## **DECISION-MAKING PRACTICE IN YOUTH SOCCER: A CROSS-COMPARISON OF COACHING CONTEXTS FROM TOP-DIVISION PROFESSIONAL CLUBS IN ENGLAND, GERMANY, PORTUGAL, AND SPAIN**

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Decision-making practice in youth soccer: A cross-comparison of coaching contexts from top-division professional clubs in England, Germany, Portugal, and Spain

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### INTRODUCTION:

A key performance attribute that discriminates highly-skilled soccer players from their lesser-skilled counterparts is the ability to anticipate and make effective decisions under pressure during match play (e.g., [1]). Researchers have shown that these 'game intelligence' skills are primarily acquired through activities in which practice has the same underlying structure as competition (e.g., [2]). The aim of this study was to investigate the structures of practice activities used by youth soccer coaches working in the youth academies of professional top-division clubs from England, Germany, Portugal, and Spain. This was the first study to assess the microstructure of coach-led practice in youth soccer across multiple countries.

### METHODS:

Altogether, 53 male soccer coaches working with under-12 to under-16 age group male players across 16 youth academies of professional top-division clubs in four European nations took part. A total of 83 practice sessions were analysed in situ. Sessions were analysed for the proportion of time in 'non-active decision-making' (e.g., unopposed technical or tactical skills practices, fitness training) and 'active decision-making' activities (e.g., small-sided games, skills practice with opposition), with the latter deemed superior for the transfer of 'game intelligence' skills to match play.

### RESULTS:

More time was spent in active decision-making (M = 62%) compared to non-active decision-making activities (M = 20%) and transitioning between activities (M = 17%). Players from Portugal and Spain spent a higher amount of time in active decision-making activities compared to English and German players. English players spent more time in unopposed technical-based drills and German players in improving fitness aspects of the game without the ball.

### CONCLUSION:

Our findings extend previous research assessing coach-led youth soccer practice in single countries by demonstrating differences in specific training activities and environments between youth academies at professional clubs in multiple European countries.

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## **TRAINING LOAD RESPONSES MODELLING IN ELITE SPORTS: HOW TO DEAL WITH GENERALISATION ?**

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### INTRODUCTION:

Training load responses modelling in the way of performance optimisation is one of the most sport science studied topic since decades. While Banister et al. (1975) aimed to model the relationship between training and performance, statistics and informatics fields provides some further benefits. However, the generalisation ability of traditional models remains unknown and physiological interpretation drawn from these models have to be carefully reconsidered. Elite sport data are generally characterised by a few observations to model but also plenty of explanatory variables, according to the rise of wearable sport devices. Thus, we hypothesised that cross-validation procedures

within a data-driven approach and regularisation methods would be more efficiency to understand the training -performance relationship and to predict futures performances. In the present study, we provided a methodology relying on generalisation ability in a context of elite sport performance modelling.

**METHODS:**

Seven Olympic Short-track speed skaters participated to the study. Training load was calculated from the mechanical energy demand during exercise and supported by subjective information (e.g. rate of perceived exertion). Independent variables were aggregated following two exponential models with (i) an impulse response model and (ii) a serial and bi-exponential response model, in order to account for past training sessions in modelling.

Generalisation of the reference variable dose-response model (Busso, 2003), statistical models and machine-learning models (individual and group based models) was assessed within a time series cross-validation procedure (CV) (Arlot et al., 2010).

Model performance were described by the root mean square error (RMSE) on each dataset.

**RESULTS:**

Performance of each models were significantly different than the reference model. Significant greater RMSE during CV were found for the dose-response model when compared to regularisation models and some of the machine-learning models. The dose-response model was also less sensitive to the data than other computed models.

**CONCLUSION:**

The dose-response model was outperformed by especially regularisation methods which proved their efficiency in this context. A few machine-learning models were prone to overfitting, mostly due to a small sample size. Even though the results are data-dependent, the methodology provided in the present study could be applied regardless of the sport discipline.

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## OP-BM01 Neuromuscular physiology, Fatigue and Performance

### ASSESSMENT OF MUSCLE FATIGUE AND FATIGABILITY AFTER INTERMITTENT SUBMAXIMAL EXERCISES

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**INTRODUCTION:**

Muscle fatigue (MF) is defined as any exercise-induced reduction in the ability to exert muscle force or power (Gandevia, 2001) and is commonly quantified as the reduction of maximal torque generating capacity. Rudroff et al. (2010) studied MF induced by fatiguing tasks with different feedback controls. Even if the torque-time integral (TTI) was different between tasks, the maximal voluntary contraction (MVC) loss was similar. This finding rises doubts about the relevancy of MVC loss as the gold standard index of MF. Byrne and Eston (2002), observed that eccentrically exercised muscle was characterized by a reduced ability to generate maximal force (i.e. MVC loss), but an improved ability to maintain force (during a MVC sustained for one minute: MVC1-min). In view of these considerations, the present study aimed to examine the relevancy of the MVC1-min to assess MF. To this end, we proposed to use a sustained MVC of 1-min duration before and after fatiguing tasks.

**METHODS:**

Thirteen healthy volunteers ( $23.5 \pm 2.0$  y.o) performed a MVC1-min of the plantar flexors (PF) before (pre) and after (post) the completion of the following fatiguing tasks: intermittent (10s on, 5s off) isometric voluntary (VOL) and neuromuscular electrical stimulated (NMES) contractions of PF at 20 and 40% of MVC throughout 4 distinct sessions. The muscle workload was matched between VOL and NMES tasks for both 20 and 40% MVC.

**RESULTS:**

Regardless of muscle contraction modality (i.e. VOL or NMES), we observed that despite the greater TTI for the 40% MVC task compared to the 20% MVC one (respectively  $20438 \pm 2939$  Nm.s vs.  $12009 \pm 2340$  Nm.s,  $p < 0.001$ ), the MVC was similarly reduced by both tasks (pre =  $110.6 \pm 23.5$  Nm, post =  $98.2 \pm 21.3$  Nm,  $p < 0.001$ ), while the MVC1-min was more reduced by the 40% MVC task (pre =  $-37.0 \pm 12.4$  %, post =  $-49.1 \pm 13.1$  %,  $p < 0.001$ ).

**CONCLUSION:**

The identical MVC loss, induced by the 40% and the 20% MVC tasks paradoxically seems to suggest that the exercise with the largest workload is less fatiguing. On the other hand, the greater MVC1-min loss after the 40% MVC task implies that the more intense exercise is actually more fatiguing. Thus, the single MVC loss does not seem to be the gold standard index to quantify neuromuscular fatigue. The present study clearly shows that for an appropriate quantification of MF, the force loss after a sustained MVC (i. e. MVC1-min) is necessary and should always be associated with the MVC loss.

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### NEUROMUSCULAR FATIGUE DURING REPEATED SPRINTS ASSESSED WITH AN INNOVATIVE ERGOMETER.

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**INTRODUCTION:**

Repeated sprint ability (RSA) is paramount in intermittent exercises as team sports. To date, there is no consensus on the respective contribution of the central and peripheral neuromuscular fatigue (NMF) in the limitation of such exercise, partly due to methodological considerations, as the time required between exercise cessation and fatigue evaluation (30 to 180 s) (1), or the lack of individualization in exercise modalities (e.g. a given number of sprints inducing various fatigue levels between subjects). To circumvent this limitation, we developed an instrumented cycle-ergometer allowing NMF to be assessed with no delay after a sprint. This study aimed to evaluate fatigue development and its etiology during and immediately after a cycle repeated sprint exercise performed until a given fatigue threshold.

**METHODS:**

Healthy males (n=11, 24 ± 6 yr, 71 ± 10 kg) realized a RSA test on a custom semi-supine bike (10-sec sprint / 28-sec recovery) until a 30% decrease in sprint mean power (Pmean). Maximum voluntary contraction of the quadriceps (MVC), central fatigue [voluntary activation (VA)] and peripheral fatigue [high-frequency doublet (Db100), twitch (Pt)] were evaluated before (pre), immediately (i.e. no delay) after each sprint and 0, 3 and 5 min after the test. For each RSA test, sprints were expressed as a percentage of the total number achieved. Individual data were then extrapolated at 20, 40, 60 and 80% of the test completion to be compared between subjects. Repeated measure ANOVAs and Holm correction for post-hoc tests were performed.

**RESULTS:**

Subjects realized 9.7 ± 4.7 sprints with a maximal Pmean of 585±89 W. MVC was decreased from 20% to 60% and then plateaued (pre: 344±57 N, 20%: 307±63 N, 60% 261±53 N, 100%: 247±55, F(7,70)=21.7, p<0.001). Db100 and Pt decreased from 20% and plateaued after 60% (F(7,70)=45.2, p<0.001, pre-60% = -32.4±9.2%) and 40% (F(7,70)=44.0, p<0.001, pre-40% = -43.3±8.2%), respectively. VA was not significantly affected by RSA test until 80% and the end of the RSA test (pre-post = -4.9±5.7%, F(7,70)=3.62, p=0.035). Unlike peripheral parameters, VA recovered significantly within the 3 to 5 min after the RSA test (F(3,27)=5.64, p=0.003).

**CONCLUSION:**

During a RSA tests, the decreases in Pmean and MVC were first concomitant to peripheral disturbances from the beginning to 60% of the exercise and central fatigue was only observed in the final part of the test while peripheral fatigue plateaued. The distinct recovery kinetics in central versus peripheral components of fatigue further confirm the necessity to reduce traditional delays in NMF assessments after such type of exercise.

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**INFLUENCE OF PASSIVE TENSION ON SOLEUS HOFFMANN REFLEX DURING PLANTAR FLEXOR MUSCLES STRETCHING**

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**INTRODUCTION:**

The viscoelastic properties of the muscle-tendon unit (MTU) induces an increase in passive torque during MTU stretch manoeuvre whereas the amplitude of the Hoffmann (H) reflex, which assesses the net excitatory input of group I afferents to spinal motoneurons, decreases<sup>1</sup>. A recent study indicates that prolonged passive stretch of plantar flexor muscles is accompanied by an increase in H-reflex amplitude in soleus<sup>2</sup>. This suggests that the inhibitory mechanisms acting on H-reflex pathway during a muscle stretch could depend, at least in part, on the passive torque of the MTU. The present study investigated further this possibility for plantar flexor muscles.

**METHODS:**

19 subjects (24±2yr) underwent 3 different protocols, in a randomized order, consisting of passive stretching of the plantar flexor muscles from an ankle angle of 90° (thereafter referenced as 0° (neutral position)) to a 30° ankle dorsiflexion angle, relative to the neutral position. In protocol 1, the maximal H-reflex amplitude (HMAX) and compound muscle action potential (MMAX) were evoked in soleus at 0, 10, 20 and 30° during the stretching and relaxation phases. In protocol 2, HMAX and MMAX were evoked at similar angles that in Protocol 1 during two stretching phases separated by a constant angle stretch hold at 30° during 5 min to decrease the MTU passive torque prior to the second stretching phase. In protocol 3, HMAX and MMAX were evoked at similar ankle angles that Protocol 1 during the stretching phase while the ankle angles during the relaxation phase was adjusted to match the passive torque recorded during the stretching phase.

**RESULTS:**

In Protocol 1, the passive torque increased (+34 Nm) and decreased during the stretching and relaxation phases, respectively (p<0.05), but was significantly lesser at each angle during the relaxation than the stretching phase (p<0.05). The HMAX amplitude decreased (-27%MMAX) and increased (+33%MMAX) during the stretching and relaxation phases, respectively (p<0.05), but was significantly greater at each angle during the relaxation phase (p<0.05). In Protocol 2, the lesser passive tension during the second stretching phase, compared with the first, was accompanied by a greater HMAX amplitude (p<0.05). In Protocol 3, the HMAX amplitude was similar during the stretching and relaxation phases (p>0.05).

**CONCLUSION:**

Our data indicate that the modulation of the H reflex during stretching relates the change in the passive torque of the MTU, such that the lesser the passive torque, the greater the H-reflex amplitude. These results suggest that part of the inhibitory mechanisms reducing the net excitatory group I afferent input onto motoneurons<sup>1</sup> during stretching, may depend on the passive torque developed by the MTU.

**NEUROMUSCULAR FATIGUE IN INDIVIDUALS WITH CEREBRAL PALSY AND HEALTHY CONTROLS: A PILOT STUDY.**

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**INTRODUCTION:**

Cerebral Palsy (CP) is a non-progressive neurological disease caused by a perinatal injury. Physical fatigue is a main limitation in this population and affects their quality of life. However, there are still controversial results on the underlying neurophysiological mechanisms of fatigue in CP (1).

The aim of the study was to assess the contribution of the two components – central and peripheral – of neuromuscular fatigue (NMF) in this population. We hypothesized the neural drive to the muscle to be modified in CP, exacerbating the level of central fatigue.

**METHODS:**

Central and peripheral components of NMF were assessed via interpolated twitch technique in young adults with CP and typically developing (TD) age-matched subjects. Participants performed six maximal isometric contractions of the quadriceps muscle before- and after a

dynamic leg-extension exercise to exhaustion (TL). Maximal voluntary contractions (MVC), electrically evoked resting twitch (Qtwpot) and voluntary muscle activation (VA) were calculated. During the fatiguing test, metabolic and cardiovascular parameters were recorded. TD subjects performed an additional session, this time exercising with same workload of their CP-match (TLiso), allowing for additional comparisons.

#### RESULTS:

Preliminary results of three CP-TD matches are discussed. MVC (CP:  $332.6 \pm 80.8$ , TD:  $451.9 \pm 22.2$  N), VA (CP:  $62.4 \pm 12.2$ , TD:  $84.6 \pm 4.4\%$ ) and Qtwpot (CP:  $124.3 \pm 46.4$ , TD:  $240.7 \pm 103.6$  N) pre-exercise values were lower in individuals with CP. Peak single-leg exercise workload (CP:  $23 \pm 3$ , TD:  $83 \pm 25$  W) and metabolic efficiency (CP:  $2.9 \pm 2.2$ , TD:  $4.6 \pm 0.6\%$ ) were lower in CP group. Oxygen consumption (VO<sub>2</sub>) at rest and during exercise was similar between groups. Time to exhaustion (CP:  $865 \pm 318$ , TD:  $347 \pm 115$  s) was higher in participants with CP. During TLiso session, TD participants did not exhaust within 30 min. Fatigue-induced changes in MVC and Qtwpot were similar in CP and TD in session "TL" (MVC: -18 and -19%; Qtwpot: -20% and -45%, respectively), whereas VA was reduced only in CP group (CP: -8%, TD: +3%). The same parameters did not change in TD after the "TLiso" session.

#### CONCLUSION:

Results of reduced VA in CP group seem to agree with our hypothesis of impaired neural drive to muscle. Nevertheless, when compared to TD, subjects with CP exercise for longer time at a relative high intensity. This is likely due to an adaptation of their neuromuscular system. Our results confirm that individuals with CP are weaker than TD peers. This limitation seems partially due to sub-optimal ability to activate the muscle and to a reduced metabolic efficiency eventually caused by co-contractions of antagonist muscles and alterations in muscle properties.

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### IMPACT TRANSMISSION IN THE TIME AND FREQUENCY DOMAIN DURING RUNNING AFTER CENTRAL AND PERIPHERAL FATIGUE.

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#### INTRODUCTION:

Fatigue could increase the severity of the impact during running and the risk of stress injuries. Most studies evaluated impact transmission in the time domain analysis. But fatigue is derived from alterations in muscular or peripheral and spinal or central mechanisms (1) and there are no studies that compare the effects of both types of fatigue on running impacts. Time domain analysis offers less detail than the frequency domain which is less used, but analyzing the low (movement) and high (severity of impact) components allows to determine the transmissibility of the impact (2). The objective was to compare impact transmission using both analysis between central and peripheral fatigued state during running.

#### METHODS:

18 male recreational runners (age:  $28.2 \pm 8.6$  ys, height:  $1.77 \pm 0.65$  m, mass:  $71.74 \pm 8.44$  kg, maximal oxygen consumption [VO<sub>2</sub>max]:  $62.2 \pm 4.7$  ml/kg/min, and experience:  $7.3 \pm 5.3$  years) participated on 3 separate days. The maximal aerobic speed (MAS) was registered in the first day. In the second and third day the effects of central and peripheral fatigue on impacts was measured. Central fatigue and peripheral fatigue were induced by a 30-minute running protocol at 85% MAS on a treadmill and an isokinetic dynamometer protocol in quadriceps and hamstrings muscles respectively. Impact transmission and attenuation in both analyses were registered using two accelerometers placed in the tibia and head. Before and after the both fatigue protocols, participants run 2 min at 3.89 m/s and at a 0% slope on a treadmill recording these parameters in the last 30 seconds.

#### RESULTS:

Time domain variables were not modified neither with peripheral or central fatigue ( $p > 0.05$ ). Nevertheless, central fatigue increased the maximum ( $p = 0.006$ ) and total ( $p = 0.007$ ) impact or signal power magnitude in the high-frequency components in the tibia, and the attenuation of low ( $p = 0.048$ ) and high-frequency components ( $p = 0.000$ ). Peripheral fatigue did not cause modifications to the frequency domain variables. Further, the attenuation in low ( $p = 0.000$ ) and high-components were higher with central fatigue than peripheral fatigue ( $p = 0.003$ ).

#### CONCLUSION:

Acceleration in the tibia were not altered after central fatigue, coinciding with Mercer et al (3). Our results agree with studies in which central fatigue increased the severity of high-frequency impacts in the tibia location (4). These findings contradict those obtained in the time domain analysis. But the frequency domain analysis determines directly the transmissibility of the impact in the human body and it is more accurate (4). Central fatigue increases the severity of impacts, as well as the attenuation of low and high components. It supports that frequency domain analysis is more sensitive when evaluating the severity of impacts during running.

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### MEASUREMENT OF INTRACORTICAL AND CORTICOSPINAL INHIBITION WITH FATIGUE – IS LESS MORE?

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UNIVERSITY JEAN MONNET

#### INTRODUCTION:

Previous research has suggested that measuring short-interval intracortical inhibition (SICI) and the transcranial magnetic stimulation (TMS) evoked silent period (SP) using intensities which evoke submaximal responses could provide the most sensitive method of assessing fatigue-induced changes in these variables (1,2). However, this have never been systematically investigated. The present study examined the effects of using conditioning stimulus (CS; Experiment A) and single-pulse TMS intensities (Experiment B) which elicit maximal and submaximal SICI/SP duration (MaxSICI vs SubmaxSICI – Experiment A, MaxSP vs SubmaxSP – Experiment B) on the change in these measures in the knee extensors with fatigue.

#### METHODS:



In both experiments, participants performed a 10 min sustained isometric contraction at a constant level of EMG, with measures taken using maximal and submaximal intensities at baseline and every 2.5 mins throughout the task. Immediately following the 10 min contraction, responses were measured at the same absolute force level as with baseline. Recovery measures were taken at both the constant EMG and absolute force levels at 2- and 6-mins post-exercise. In both experiments, a two-way ANOVA was used to assess the effect of the evoked baseline SICl (Experiment A) and SP (Experiment B) on its change with fatigue.

### RESULTS:

In Experiment A, no change in SICl was observed with either CS intensity throughout the EMG task ( $P < 0.35$ ). However, a decrease in SICl (i.e. less inhibition) was observed during all post-exercise measurements taken at the same absolute force only when using the MaxSICl CS intensity ( $P < 0.02$ ), with no change in SubmaxSICl. Specifically, MaxSICl changed from 62% at baseline to 80% immediately post-exercise ( $P < 0.01$ ), while SubmaxSICl went from 80 to 83% ( $P > 0.05$ ). In Experiment B, the increase in SP at both constant EMG and force levels occurred irrespective of TMS intensity ( $P < 0.05$ ), however, increases in motor evoked potential (MEP) amplitude at the same absolute force level following the EMG task were only detected using the stimulus intensity associated with SubmaxSP.

### CONCLUSION:

The results from this study suggest that 1) CS intensities which elicit optimal SICl are more sensitive to detecting fatigue-induced decreases in SICl; 2) increases in SP can be detected using intensities which elicit either maximal or submaximal SP durations at baseline and; 3) changes in corticospinal excitability in response to sustained low-intensity contractions are more detectable using intensities which elicit submaximal MEPs. Given that inter-subject variability exists between the CS intensity used to evoke maximal SICl, studies should optimise CS intensities individually prior to examining fatigue-induced effects on SICl rather than utilising a “one-size-fits-all” approach.

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## NEUROMUSCULAR JUNCTION TRANSMISSION STABILITY AND MOTOR UNIT FIRING RATES ACROSS STAGES OF THE MENSTRUAL CYCLE IN EUMENORRHEIC WOMEN

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### INTRODUCTION:

The menstrual cycle in healthy females is largely defined by fluctuations of the sex hormones oestrogen, progesterone, luteinising hormone (LH) and follicular stimulating hormone, all of which are at their lowest point during menstruation, followed by a rapid increase of oestrogen and LH during ovulation [1]. These varying hormone levels exert significant systemic physiological impacts including neuro-excitatory and -inhibitory effects which may impact upon neuromuscular performance at the recreational and elite athlete level [2-4]. As clear mechanistic insight of neuromuscular function is lacking, we utilised intramuscular measures of electrophysiology to determine whole muscle and individual motor unit (MU) function in the vastus lateralis (VL) at different stages of the menstrual cycle.

### METHODS:

Home ovulation kits were used to confirm cycle phase in five eumenorrhic females (age;  $24.5 \pm 2.72$  years, VL CSA;  $17.32 \text{ cm}^2$ , BMI;  $21.9 \pm 2.92 \text{ kg.m}^2$ ) and neuromuscular assessments were performed during menses (C1) and ovulation (C2). Neuromuscular strength and control of the knee extensors were assessed isometrically with force steadiness quantified as force fluctuation of contractions held at 25% of maximum voluntary contraction (MVC). Intramuscular needle electrodes were used to sample individual VL MU potentials (MUP) at 25% of MVC at a range of depths and directions. Firing rates were quantified by the number of observations of the same MUP per second (Hz). Neuromuscular junction (NMJ) transmission stability was quantified as the variability in ‘near fibre’ MUP shape of consecutive firings of the same MU.

### RESULTS:

Maximum voluntary contraction and force steadiness did not differ between C1 and C2 phases ( $p=0.641$  and  $p=0.735$ , respectively). A total of 24 (28) MUs were sampled in each participant at each time point. Univariate analysis (participant and phase as fixed factors) revealed firing rates differed across participants ( $p < 0.0001$ ) but did not differ between phases of the menstrual cycle (C1;  $8.64 \pm 1.01$  vs C2;  $8.63 \pm 0.83$  Hz,  $p=0.975$ ). Neuromuscular junction transmission stability did not differ across participants ( $p=0.449$ ) or according to stage of the menstrual cycle (C1;  $16.31 \pm 5.98$  vs C2;  $17.28 \pm 6.43$  %,  $p=0.566$ ).

### CONCLUSION:

Results demonstrate no differences in neuromuscular performance assessed by strength and control between cycle phases in eumenorrhic females. Motor unit firing rates and NMJ transmission stability did not differ between menstruation and ovulation phases of the menstrual cycle. Expansion on participant numbers and assessment of other phases of the cycle is warranted to provide definitive conclusions.

## OP-BM02 Walking, Running, Jumping

### CIRCULATING MICRORNAs: BIOMARKERS OF MUSCLE DAMAGE AFTER A 24-HOUR ULTRAMARATHON RUN IN ELITE ATHLETES

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### INTRODUCTION:

Whether the delayed muscle function loss is considered as the best measure for evaluating the magnitude of exercise-induced muscle damage, immediate measure may reflect muscle fatigue rather than muscle damage [1]. Novel biomarkers could be useful to predict loss of muscle function measured 24h after the exercise. The aim of the present study was to: 1) examine the acute response of muscle damage biomarkers to the 24-h run World Championships in elite runners 2) investigate the relevance of circulating microRNAs (miRNAs) as early biomarkers of muscle damage.

### METHODS:

Eleven French elite athletes (5 men, 6 women) performed  $230.5 \pm 24.4$  km during a 24-h ultramarathon World Championship. Counter-movement jump (CMJ) height, creatine kinase (CK), myoglobin (Mb), muscle-specific miRNAs were measured before, immediately after, 24 and 48h after the race. CMJ height was measured using an Optojump photocell system (Microgate, Bolzano, Italy). Serum CK and Mb were measured using a Roche Cobas c501 autoanalyzer (Roche Diagnostics GmbH, Mannheim, Germany). Plasma miRNAs analysis was performed by Real-time quantitative RT-PCR.

**RESULTS:**

CMJ height was reduced by  $84.0 \pm 25.2$  % immediately after the exercise ( $p < 0.001$ ) and remains reduced 24h after the race ( $-43.7 \pm 20.4$  %;  $p = 0.002$ ). An increase of CK ( $42914 \pm 59667$  U/L;  $p < 0.001$ ) and Mb ( $9748 \pm 7997$  ng/mL;  $p < 0.001$ ) was observed immediately after the exercise and remains elevated 24h after ( $p < 0.01$ ). An increase of circulating miRNAs levels (miR-1-3p, miR-133a-3p, miR-133b-3p, miR-206-3p, miR-208a-3p, miR-208b-3p, miR-378-3p, miR-499-5p) was observed immediately after the 24-h run (fold change: 18 to 124723;  $p < 0.001$ ) and remains elevated 24h after the end of exercise for miR-499-5p ( $p < 0.05$ ). Circulating levels of miR-208a-3p and 208b-3p at the end of the ultramarathon were significantly correlated with CMJ height loss at 24-h ( $p < 0.05$ ) and approached significance for miR-1-3p, miR-133a-3p, miR-133b-3p, miR-499-5p ( $p < 0.07$ ). No significant correlation was found between CMJ height loss at 24h and CK ( $p = 0.91$ ) or Mb ( $p = 0.31$ ).

**CONCLUSION:**

All elite marathon runners included in our study were diagnosed with exertional rhabdomyolysis (CK > 10000 U/L). Muscle-specific miRNAs seem to be early biomarkers of exercise-induced muscle damage and could be used to predict loss of muscle function measured 24h after the exercise.

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**RELIABILITY OF THE OUTCOMES OF PRINCIPAL COMPONENT ANALYSIS WHEN ANALYZING THE COORDINATIVE STRUCTURES IN GAIT: PROOF OF CONCEPT**

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UNIVERSITÄT INNSBRUCK

**INTRODUCTION:**

Principal Component Analysis (PCA) is a data-driven (1) tool increasingly applied for analyzing coordinative structures in whole-body movements (1,2). It has been argued (3,4) that PCA provides a coordinate system adapted to the analyzed motion, which would imply that the PCA outcome is motion-specific and to some degree independent of the specific data used to characterize this motion. The current proof-of-concept study tests the hypothesis that principal movement components obtained from the same motion, but from PCAs based on two independent measurement systems (Vicon™; Xsens™) provide the same information.

**METHODS:**

Two participants walked on a treadmill for 2 minutes at 4 km/h. They wore an Xsens Link suit with 17 inertial measurement units distributed over the whole-body providing segment and joint position data. A 10-camera VICON motion capture system captured the position of 39 markers (full-body plugin-gait) A MATLAB based software package for PCA analysis (4) was used to analyze both participants separately. The first 8 Principal Components (PCs) were cross correlated between the Vicon- and the XSense-based datasets.

**RESULTS:**

In all participant-apparatus pairings, PC1 explained over 80% and the first three PCs together explained at least 97% of the variance. For PC1, correlation between the PC1vicon and PC1Xsens was strong ( $r > .95$ ) in both test subjects. For three PCs that explained most variance, the PC1vicon -PC1Xsens correlation was excellent ( $r > .9$ ) in one volunteer and very strong ( $r > 0.84$ ) in the other. In higher PCs, the correlation gradually decreased, and the order flipped between PC components.

**CONCLUSION:**

The current study suggests that PC1 results for walking can reliably be compared even between datasets obtained from different measurement systems, provided that the systems recorded whole-body motion data. For the first 3 movement components, strong correlations were observed, suggesting that these movement components carry largely the same information, even if they were obtained from different measurement systems. The results of the current study are similar or better than between-day repeatability reported for joint angle data (5), or for multi-center comparisons of kinematic data (6). We conclude that low-order PCs are motion-specific and provide the same information even for data obtained from different measurement systems. Future research should investigate other forms of motion, e.g. running, and assess the influence of weighing the data, e.g. with segment weights.

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**PREDICTION AND CLASSIFICATION OF FOOT STRIKE DURING RUNNING USING THE LOADSOLTM INSOLE PRESSURE SENSORS: AN ECOLOGICALLY-VALID FOLLOW-UP STUDY**

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**INTRODUCTION:**

The foot strike pattern performed during running is an important variable for runners, performance practitioners, and industry specialists. Foot strike estimation models generated within laboratory constraints (i.e. short runway distance or speed restrictions), may not be applicable for lab-to-field research applications. Thus, the purpose of the current study was to determine the accuracy and precision of foot strike angle prediction and pattern classification models (generated from running foot falls performed within laboratory constraints) when applied to ecologically valid running conditions.

**METHODS:**

Two Random Forest machine learning models (1) were trained to i) predict the foot strike angle and ii) classify the foot strike pattern of laboratory-constrained running (LAB) foot falls using independent variables from Loadsol™ insoles (30 participants; 70% training set = 2442 steps, validation set = 1047 steps). A sample of ecologically valid foot falls (ECO) were collected from a new set of participants (n = 19; steps = 2202) and applied to the models. Foot strike pattern classes (fore foot – FF, mid foot – MF, rear foot – RF) were consistent with predefined ranges (2). Prediction model accuracy metrics (via root mean square error - RMSE and mean absolute error – MAE) (3) and Bland-Altman bias and precision (4) were calculated for the LAB validation set and the ECO sample separately. Classification model accuracy, recall, and precision were calculated from confusion matrices (3) for the LAB validation set and the ECO sample.

**RESULTS:**

The ECO data set resulted in lower prediction accuracy and precision than the LAB validation set (RMSE: ECO=8.55, LAB=3.65; MAE: ECO=6.86, LAB=2.69; Bland-Altman bias: ECO=-6.14, LAB=-0.11; Bland-Altman maximum precision: ECO=23.33°, LAB=14.30°). The classification model had higher model performance with the LAB set than the ECO set (overall accuracy: ECO=65.8%, LAB=94.1%). Of the three foot strike patterns, the MF condition classified with the least recall and precision (ECO recall: FF=22.9%, MF=60.3%, RF=95.3%, ECO precision: FF=94.5%, MF=59.4%, RF=68.3%). This was consistently lower than the LAB recall and precision (LAB recall: FF=96.3%, MF=76.7%, RF=96.4%, LAB precision: FF=95.9%, MF=74.8%, RF=97.0%).

**CONCLUSION:**

The machine learning models generated for the prediction and classification of foot strike perform better in the LAB environment, which was consistent with the data used to train the models. However, the evidently good classification recall of RF ECO running suggests that similar models may be generated from ECO and LAB RF foot falls. Importantly, when applying future prediction and classification models, the modelling environment should reflect the environment in which the models will be applied.

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**CHANGING STRIDE FREQUENCY ALTERS TRICEPS SURAE MUSCLE DYNAMICS DURING RUNNING.**

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KU LEUVEN

**INTRODUCTION:**

Although the stride frequency at which runners prefer to run varies considerably, every runner's preferred stride frequency (PSF) closely matches their metabolically optimal stride frequency [1]. While the concept of self-optimization is well supported within research, it is still unclear why a certain stride frequency corresponds with minimal energy consumption. Yet, we know that changing stride frequency alters lower limb kinetics and kinematics possibly influencing the Triceps Surae muscle-tendon interaction, an important factor for metabolic energy consumption during running [2]. In this study, we investigated the effect of different stride frequencies on the Triceps Surae muscle dynamics.

**METHODS:**

Eight experienced runners (6M, 2F) performed five running trials at different stride frequencies (PSF, PSF ± 8% and PSF ± 15%) while running at 12 km/h. During the running trials, we collected ground reaction force data, lower limb kinematics, whole body metabolic energy expenditure, Gastrocnemius medialis (GM), Gastrocnemius lateralis (GL) and Soleus (SOL) muscle activity and dynamic ultrasound images of the SOL and GM muscles.

**RESULTS:**

We found significant differences in average fascicle length but not velocity of GM and SOL during stance. In general, average fascicle length of GM and SOL was largest when running at preferred stride frequency. Post-hoc analysis revealed 7% longer average fascicle lengths at the preferred stride frequency compared to the -15% condition for GM. SOL average fascicle lengths were respectively 7% and 6% longer at the preferred stride frequency compared to the -15% and +15% condition. Since both GM and SOL work on the ascending limb of the force-length relationship during running [3,4], from a muscle metabolic energy perspective, operating at shorter muscle length is likely to increase energy consumption. Moreover, our muscle activation data seems to further support this suggested increase in Triceps Surae muscle metabolic energy consumption as integrated EMG signals during stance were significantly higher for GM, GL and SOL when running at the -15% condition compared to the preferred stride frequency condition.

**CONCLUSION:**

Our results suggest that the optimal stride frequency may be (partially) explained by more favourable operating conditions for the Triceps Surae muscle. Especially at stride frequencies lower than the optimal frequency, in vivo muscle dynamics as well as muscle activation data indicate increased energy consumption by the Triceps Surae muscle.

**STEP FREQUENCY DIFFERENCES ALTER THE ENERGETICS AND AVERAGE JOINT POWER IN RUNNING**

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KU LEUVEN

**INTRODUCTION:**

Runners intrinsically select a step frequency close to the metabolic optimal frequency, otherwise known as self-optimization [1]. Running energetics have been previously shown to be minimized when running at the preferred step frequency (PSF), while it increases when running at altered step frequencies, following a U-shaped curve [2]. Furthermore, the metabolic cost of running at PSF can be subdivided into a ground contact and leg-swing phase, each accounting for 80% and 7% of the whole-body metabolic cost respectively [3]. The majority of the mechanical work during the energetically expensive ground contact phase occurs at the ankle joint [4], while the hip extensor muscles contribute the most during the leg-swing phase [5]. Previous research already demonstrated that joint kinetics and kinematics alter with changes in step frequency [6]. In this study, we investigate whether changes in average joint power may explain the changes in metabolic energy consumption when running at altered step frequencies.

**METHODS:**

Seventeen experienced runners performed six running trials in a randomized order at different step frequencies relative to their PSF [-15%, -8%, PSF (x2), +8%, +15%], at a constant treadmill speed of 12 km/h. Indirect calorimetry was used to determine the whole-body metabolic

energy consumption. Kinetics and kinematics were collected by means of 3D-motion capture and force plates embedded in the treadmill to determine the average joint power [7] at the lower-limb joints.

#### RESULTS:

The whole-body metabolic energy consumption followed a U-shaped curve, with all conditions except the +8% condition, showing significant differences from the lowest value representing the PSF.

Average positive ankle joint power during ground contact increased by 19% when step frequency was reduced from +15% to -15%. During leg-swing, running at +15% led to a 65% increase in positive hip joint power compared to the -15% condition.

#### CONCLUSION:

These results suggest that the economical Triceps Surae muscles might consume more energy at lower step frequencies during the energetically expensive ground contact phase. On the contrary, when running at step frequencies higher than preferred, the hip muscles during leg-swing might consume more energy, therefore possibly exceeding the proposed contribution of 7% to the metabolic cost. Running at the metabolic optimal step frequency might therefore represent a trade-off between positive ankle power during ground contact and hip joint power during leg-swing.

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### THE EFFECT OF SHOE CUSHIONING ON LANDING IMPACT FORCES AND SPATIOTEMPORAL PARAMETERS DURING RUNNING: RESULTS FROM A RANDOMISED TRIAL INCLUDING 800+ RECREATIONAL RUNNERS

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#### INTRODUCTION:

The cushioning of running shoes is considered a key feature to modulate external loads applied to the musculoskeletal system and, possibly, influence running injury risk. In a recent randomised trial including 800+ recreational runners with a 6-month follow-up, injury risk was lower in those who received the Soft shoe version compared to those using the Hard version (Hazard ratio=0.67; 95% Confidence Interval=0.47-0.94). Therefore, the main objective of this study is to seek a functional explanation to the protective effect of the Soft shoe version observed previously. Here, we present a comparison of the kinetic and spatiotemporal data from our two study groups, to investigate the influence of shoe cushioning on running biomechanics.

#### METHODS:

This double-blinded randomised trial included 848 healthy runners who randomly received one of two shoe prototypes that differed only in their cushioning properties (Global stiffness:  $61 \pm 3$  and  $95 \pm 6$  N/mm in the Soft and Hard versions, respectively). Participants were tested on an instrumented treadmill in the allocated study shoes at baseline. Ground reaction force (GRF) data was recorded over 2 minutes at the participant's preferred running speed. An analysis of variance was used to compare the mean results between the two study groups, with speed as co-variable.

#### RESULTS:

Mean running speed during the test was  $9.9 (\pm 1.5)$  km/h. The number of steps analysed per participant was  $325 \pm 19$ . No difference was observed among the spatiotemporal variables. A higher Vertical Impact Peak Force (VIPF) was observed in the Soft shoe group compared to the Hard shoe group ( $1.53 \pm 0.21$  vs.  $1.44 \pm 0.23$  BW, respectively;  $p < 0.001$ ). However, the proportion of steps with detectable VIPF was lower in the Soft shoe group (84 vs. 97%, respectively;  $p < 0.001$ ) and Time to VIPF was longer ( $46.9 \pm 8.5$  vs.  $43.4 \pm 7.4$  milliseconds, respectively;  $p < 0.001$ ). No significant difference was observed between the two study groups for Vertical Instantaneous Loading Rate (VILR;  $60.1 \pm 13.8$  vs.  $58.9 \pm 15.6$  BW/s for Soft and Hard shoe group, respectively;  $p = 0.070$ ), or any other kinetic variable.

#### CONCLUSION:

In contrast to what might be expected, runners from the Soft shoe group had greater VIPF compared to the Hard shoe group, while no difference was found for VILR. On the other hand, time to VIPF was longer and the proportion of steps with detectable VIPF was lower in participants with the Soft shoe version. As our previous prospective follow-up of this cohort revealed that injury risk was lower in the group with the Soft shoe version, the current results show that the beneficial effect of greater cushioning cannot be explained by a decrease in VIPF or VILR. Taken alone, these GRF metrics are likely not appropriate markers to illustrate the relationship between shoe cushioning and injury risk, while delayed VIPF and the proportion of steps displaying a VIPF may be of relevance here.

### EFFECT OF FATIGUE ON THE ELASTIC CHARACTERISTICS OF RUNNERS AFTER A 56-KILOMETER ROAD ULTRA-MARATHON

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#### INTRODUCTION:

Ultramarathons are a unique model to study the effects of systemic fatigue in athletes. The prolonged loading induces extreme mechanical and physiological stresses and can thereby give insight into the coping mechanisms and adaptive responses of the human body [1, 2]. The spring-mass model [3] has been an insightful template to study system-level mechanical behavior of runners following treadmill [1] and trail ultramarathons [4], but it has not been used to study the effects of a road event. It was hypothesized that assessing gait with this template would provide new insights into runners' responses to systemic fatigue.

#### METHODS:

Fourteen subjects completed a 56-km ultramarathon. One week before and two days after the race, subjects reported to the lab where Delayed-Onset Muscle Soreness (DOMS) scores for the lower limbs were assessed via Visual Analog Scales (VAS), and ground reaction forces (GRF) were recorded (2000 Hz) during overground running at 70% of their personal Peak Treadmill Running Speed (PTRS). Effective spring-mass behavior was assessed from the vertical GRF time series for each runner via nonlinear regression [6], where the session (pre-

vs. post-race) was treated as a fixed effect, and the subject and his/her condition were random effects. Parameters estimated included effective stiffness ( $k^*$ ), touchdown angle ( $a^*$ ), leg length ( $L^*$ ), contact time ( $t^*$ ), and elastic similarity. Traditional spring-mass measures [3] were also assessed via mixed-model linear regression.

**RESULTS:**

The average finish time was  $5.7 \pm 0.8$  hours. DOMS scores were significantly higher in all muscle groups after the ultramarathon ( $p < 0.01$ ). Peak vertical and braking GRFs were unchanged, while contact time decreased ( $-5$  ms,  $p < 0.001$ ), stride frequency increased ( $+2.6$  spm,  $p = 0.001$ ), and duty factor remained unchanged. The effective spring-mass parameters of the group were  $k^* = 14.2 \pm 2.5$  kN/m,  $a^* = 67.9 \pm 5.0$  deg,  $94.7 \pm 40$  cm, and  $t^* = 214 \pm 3$  ms, but the effect of the race was not significant. With respect to traditional spring-mass measures, leg stiffness increased ( $+0.3$  kN/m;  $p = 0.003$ ) and vertical stiffness remained unchanged. Overall similarity to the elastic system decreased after the race (PRE vs. POST: root mean-squared error  $+8.2\%$ ;  $p = 0.03$ ).

**CONCLUSION:**

Systematic mechanical behaviors in runners generally persisted despite the fatigue and stress induced by a road ultramarathon. Thus, the current results support previous findings that runners maintain gross mechanical behaviors when fatigued with small compensatory changes in spatiotemporal and spring-mass characteristics [6]. However, these findings also indicated that while runners maintained their overall mechanical behavior, the “noise” of that behavior may increase after stress, suggesting new opportunities for quantifying those deviations.

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**FAMILIARIZATION OF SPATIO-TEMPORAL PARAMETERS DURING BACKWARD WALKING**

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**INTRODUCTION:**

Backward and forward walking are moving modalities that were investigated for differences and similarities in the past [1]. Results showed that the lower body kinematics were similar in shape, but time reversed. For such comparisons, treadmills are frequently used and therefore it is required to examine the familiarisation time needed to achieve stable spatio-temporal parameters [2]. In this context, research focused primarily on discrete kinematic parameters such as joint angles at: TouchDown (TD), Midstance, TakeOff (TO) or stance/stride duration [2]. To the best of our knowledge, no study examined yet the familiarisation time needed to obtain stable kinematics during backward walking on a treadmill. Therefore, the aim of this study was to assess the spatio-temporal parameters during continuing backward treadmill walking.

**METHODS:**

Twenty participants (12M, 8F,  $29 \pm 6$  y,  $69.6 \pm 10.6$  kg,  $1.76 \pm 0.07$  m) walked randomly backward on a treadmill for 12 min at two different ( $< 0.05$ ) speeds (fixed  $2.5$  and voluntary  $2.69 \pm 0.37$  km/h). Reflective markers placed on trochanter, C7, epicondylus and malleolus lateralis/medialis, heel and 5th metatarsal. Kinematics were captured with Vicon Nexus (120 Hz) and used to determine gait events. A 5 min warm up backward walking time was given. Every minute (total 12 min) 4 gait cycles were recorded, averaged, normalized and used for further analysis. We examined the hip/knee/ankle joint angle of all/male/female at: TD/TO/Min/Max and stance time (CT). Additionally, Procrustes Analysis was used to assess the time series of the hip/knee/ankle joint angle. Shapiro-Wilk-Test, One-way repeated ANOVA with a Bonferroni correction or Friedman and Wilcoxon signed-rank test was used.

**RESULTS:**

No significant effect ( $> 0.05$ ) of walking time on 98/102 discrete spatio-temporal parameters was found. Procrustes Analysis revealed familiarization phenomena ( $< 0.05$ ) after 2 min for the hip joint angle at  $2.5$  km/h as well as for the knee joint angle after 5 min at voluntary walking speed. Significant changes were found only in CT of female subjects at a fixed speed and the male's knee joint angle at TD at voluntary speed.

**CONCLUSION:**

The main finding of this study is that the familiarization of discrete spatio-temporal parameters during backward walking could be achieved after 5 min of acclimatization period. Similar results in literature (6 min) [3], (6-7 min) [2] and (10 min) [4] for forward walking, indicating that, in general, 5-10 min acclimatization period is sufficient to obtain stable discrete spatio-temporal parameters. Contrary, Procrustes Analysis findings of the time series indicates that, for some spatio-temporal parameters differences exist that cannot be detected by the discrete value analysis method.

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**KINEMATIC AND DYNAMIC PREDICTORS OF MAXIMUM VERTICAL JUMP PERFORMANCE ON ELITE AND NON-ELITE PERFORMERS**

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**INTRODUCTION:**

Potential of muscle concentric action is frequently preceded by eccentric action with muscle stretch-shortening cycle (SSC) achieved by countermovement (CM) accelerating in the opposite direction to the intended movement with retarding and inversion immediately followed by acceleration in the direction of interest, Knudson (2007). In vivo muscle SSC has been studied as a natural action at a large number of sports with maximum vertical jump (MVJ) to evaluate the contribution of long and short CM for MVJ performance namely in com-

parison with no CM, Komi PV (2003). Previous studies emphasized elite male performers with specific training, with an open issue on ability of non-elite performers to take advantage on long and short CM at MVJ.

#### METHODS:

In order to assess the ability of non-elite performers to take advantage on long and short CM in comparison with elite performers at MVJ a small group (G1) of  $n=6$  healthy male higher education sport students ( $21.5\pm 1.4$ )yrs, ( $76.7\pm 9.3$ )kg mass and ( $1.79\pm 0.06$ )m height with no specific training and sport abilities was selected for comparison with a group (G2) of  $n=16$  male players of the Portuguese national volleyball team ( $21.4\pm 3.1$ )yrs, ( $85.2\pm 5.8$ )kg mass and ( $1.93\pm 0.04$ )m height, Carvalho (2002). Each subject on both groups performed a total of nine MVJ with 2 to 3 minutes of rest between repetition on three long CM at countermovement jump (CMJ), three short CM at drop jump (DJ) from 40 cm step and three squat jump (SJ) without CM. During MVJ trials ground reaction forces (GRF) were acquired with AMTI BP2416-4000CE force plate at 1000 Hz and Mini Amp MAS-6. Push-off, flight and ground reception phases were time delimited from vertical GRF registers (GRFz) with vertical flight height  $h_t$  obtained from  $t$  flight time and vertical flight height  $h_i$  obtained from linear impulse during upward push phase as a natural predictor of MVJ performance.

#### RESULTS:

G1 presented higher  $h_t$  at CMJ ( $0.364\pm 0.042$ )m than SJ ( $0.332\pm 0.045$ )m  $p=0.230$  and DJ40 ( $0.274\pm 0.032$ )m  $p=0.002$  with DJ presenting lower  $h_t$  than SJ  $p=0.027$  whereas G2 presented higher  $h_t$  at CMJ ( $0.433\pm 0.048$ )m than DJ40 ( $0.377\pm 0.049$ )m  $p=0.003$  both higher than SJ ( $0.326\pm 0.042$ )m with  $p<0.001$  for CMJ-SJ and  $p=0.004$  for DJ-SJ. As regards to  $h_i$  from upward impulse on push-off phase G1 presented higher value at CMJ ( $0.350\pm 0.029$ )m than SJ ( $0.309\pm 0.046$ )m  $p=0.097$  and DJ40 ( $0.277\pm 0.035$ )m  $p=0.073$  with DJ presenting lower  $h_i$  than SJ  $p=0.207$  whereas G2 presented higher  $h_i$  at CMJ ( $0.406\pm 0.045$ )m than SJ ( $0.272\pm 0.059$ )m and DJ40 ( $0.258\pm 0.061$ )m both with  $p<0.001$  and  $p=0.513$  for SJ-DJ.

#### CONCLUSION:

While G1 presented consistent results for  $h_t$  and  $h_i$ :  $CMJ \geq SJ \geq DJ$  and  $CMJ > DJ$ , G2 presented inconsistent results at  $h_t$ :  $CMJ > DJ > SJ$ ,  $h_i$ :  $CMJ > SJ > DJ$  and  $CMJ > DJ$  pointing for the need of new predictors on MVJ performance and revision of  $h_i$  and  $h_t$  estimation.

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### THE IMPACT OF 12-WEEK TRAINING PROGRAM ON AEROBIC CAPACITY AND GAIT SYMMETRY IN PEOPLE WITH TRANSTIBIAL AMPUTATION.

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#### INTRODUCTION:

Walking is an accessible physical activity recommended for improving aerobic capacity in populations with movement limitations [1]. Compared to non-amputees the aerobic demands of walking are higher in transtibial amputees (TA) [2] as are rates of joint degeneration [3], this may be related to gait asymmetry present in TA [4]. Holistic training programs aimed at increasing TA aerobic capacity need to consider gait symmetry along with strength, coordination and flexibility. We aim to explore the effect of a 12-week training program for TA on; Aerobic capacity, natural gait symmetry and maintenance of gait symmetry.

#### METHODS:

TA were recruited through NHS clinicians and excluded if they were unable to perform the tests unassisted. Ethics for the study were approved by NHS. A weekly training class included a variety of exercises adapted for TA and participants were encouraged to perform at least one aerobic activity in their own time. A 3D accelerometer was attached above the sacrum. Data for medio-lateral accelerations were extracted and through auto correlation the symmetry index was calculated such that 0 indicates perfect symmetry and 1 indicates no symmetry. The adapted six-minute walk test (6MWT) was used as a test of aerobic capacity, walking at maximum maintainable pace in a figure of 8, distance walked was recorded. All data sets were exported to Excel for further analysis. Paired T-test was used to compare means before and after the training program for; 6MWT, natural gait symmetry and the change in gait symmetry before to after the 6MWT.

#### RESULTS:

Of 109 eligible TA, 25 agreed to participate, 15 were excluded due to attrition, physical limitations or prosthetic issues. We assessed 10 participants, 8 male and 2 females. Their average age was 61 years (range 21-78 years). Significant differences were found for aerobic capacity (Pre mean  $408.8 \pm 0.32$ ; Post mean  $425.2 \pm 86.3$   $p<0.01$ ), natural gait (Pre mean  $0.59 \pm 0.32$ ; Post mean  $0.49 \pm 0.37$   $p=0.01$ ) and change in gait symmetry (Pre mean  $0.21 \pm 0.14$ ; Post mean  $0.20 \pm 0.12$   $p=0.01$ ).

#### CONCLUSION:

Overall these data suggest that a holistic 12-week training program can improve TA aerobic capacity, gait symmetry and maintenance of gait symmetry, which may allow participation in walking activities without pain or joint degeneration.

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### NEUROMUSCULAR TRUNK CONTROL INFLUENCES BIOMECHANICAL INDICATORS OF KNEE STABILITY

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#### INTRODUCTION:

Coordinated muscle activation patterns are important for posture, performance and injury prevention of the knee joint. Higher knee impact loads may also result from insufficient neuromuscular trunk control and of trunk displacement (1). This study investigates trunk mus-

cle co-contraction during jumps and landings. Main questions are: (a) Is there a difference in trunk displacement and indicators of knee stability between low and high co-contraction? (b) Do co-contraction and trunk displacement predict knee stability?

**METHODS:**

43 participants perform several lateral and vertical jumps and landings. We measured 3D full body kinematics, kinetics and electromyographic activity of m. erector spinae (ES) and m. rectus abdominis (RA). Peak knee abduction moment (KAbM) within 30% of contact time was chosen for the analysis of biomechanical indicators. Trunk muscle co-contraction was calculated as ES/RA-ratio (RESRA) and divided into two groups by median split. The influence of low or high RESRA on dependent variables was analyzed using paired two-tailed t-test. Linear regression (MLR, backward inclusion) was used to analyze the relationship between indicators of knee stability and neuromuscular trunk control ( $\alpha \leq 0.05$ ).

**RESULTS:**

In general, high co-contraction resulted in less trunk flexion ( $0.2-1.5^\circ$ ), rotation ( $0.2-2.6^\circ$ ) and higher lateral trunk lean ( $0.6-1.2^\circ$ ) with higher knee flexion ( $0.3-4.1^\circ$ ;  $0.0-0.3\text{Nm/kg}$ ), less knee abduction ( $0.9-2.6^\circ$ ;  $0.1-0.2\text{Nm/kg}$ ) and internal rotation ( $1.1-5.7^\circ$ ;  $0.0-0.1\text{Nm/kg}$ ). However, only some results had a significant level. In one-legged landings KAbM was predicted by RESRA and lateral trunk lean ( $R^2=.190$ ;  $R2adj=.148$ ;  $p=.018$ ). When jump height was increased, only co-contraction was a significant predictor in the regression model and explained 14% of variation in KAbM ( $R2adj=.121$ ;  $p=.017$ ). In two-legged Djs knee abduction (KAb) was predicted by RESRA and 3D trunk kinematics ( $R^2=.271$ ;  $R2adj=.187$ ;  $p=.023$ ), but RESRA was excluded first from the regression model, followed by trunk rotation and lateral trunk lean. Trunk flexion explained 18% ( $R2adj=.163$ ;  $p=.006$ ) of KAb. When increasing jump height, RESRA and trunk flexion remained significant predictors in the model, explaining 16% of variation in KAb ( $R2adj=.067$ ;  $p=.048$ ). In side jumps, MRL extracted RESRA, but its specific effect was below significance.

**CONCLUSION:**

On the one hand, neuromuscular trunk control only weakly predicts trunk displacement and indicators of knee stability. On the other hand, higher co-contraction is related to less KAbM and may be used as a predictor of KAbM in one-legged landings, just as co-contraction and trunk flexion as predictors of KAb. Interestingly, higher lateral trunk lean was not associated with higher KAbM. Further investigation should involve long-term studies including injury rates for the regression models.

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**ASSOCIATION OF THE GAIT SPEED AND PATTERN WITH COGNITION AND BODY COMPOSITION IN OLDER PEOPLE: THE EFICCOM PROJECT**

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**INTRODUCTION:**

In the last years, the relationships of gait and cognition have widely been studied in people over the age of 65. However, there is considerable heterogeneity in cognitive ageing and dimensions (i.e. cognitive status, cognitive impairment) This implies that different gait parameters could not be similarly associated with cognitive status, cognitive impairment or other. Better understanding of gait and cognition is important in order to identify the drivers of successful ageing. Therefore, the purpose of this study was to examine the associations of several gait speeds, from different tests, and other gait parameters with cognitive performance and body composition in older people from the EFICCOM Project.

**METHODS:**

This study included cross-sectional baseline data from the EFICCOM project (Clinical Trial registration: NCT03923712). A total of 52 older people at risk of mild cognitive impairment (range 65 to 75 years;  $69.2 \pm 3.2$  years, 19 women) participated in our study. The OptoGait, MuscleLab and MyJump systems were used to record 6 different gait speeds, stride length, cadence and step distance. To determine the cognitive status, the Mini-Mental State Examination (MMSE) questionnaire was used and cognitive impairment was evaluated by Clock Drawing Test (CDT). Electrical bioimpedance was used for body composition measurements. Linear regressions analyses were applied after adjusting for basic confounders (i.e. age, sex, body mass index and educational years).

**RESULTS:**

Significant differences were found in gait parameters and body composition by sex (all  $p < 0.05$ ). Normal and fast gait speed, stride length, cadence and step distance (all  $p < 0.05$ ) were positively associated with cognitive impairment (higher CDT score). However, none of the gait parameters was significant associated with cognitive status (MMSE) (all  $p > 0.05$ ). The gait speed from different tests, stride length, cadence and step distance were negatively associated with the total fat mass and positively with the fat free mass (all  $p < 0.05$ ).

**CONCLUSION:**

The gait speed from different tests are not associated with cognitive status but strongly associated with cognitive impairment and with a healthier body composition profile. Therefore, those older adults who walked slower presented greater cognitive impairment and worse body composition. Further studies with larger sample sizes and reporting changes with intervention are needed.

**INDIVIDUAL EMG PROFILES IN RUNNERS ARE RELATED TO THE SUBTALAR JOINT ORIENTATION**

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*UNIVERSITY OF STUTTGART*

**INTRODUCTION:**

Achilles tendon disorders appear frequently in runners. Rearfoot motion and unilateral dominant activation patterns of the m. triceps surae are discussed as important factors. Both are thought to be dependent on the inter-individual orientation of the subtalar joint axis (1,2). Although often discussed, the relationship between activation profiles and subtalar joint orientation has never been investigated.

**METHODS:**

20 healthy subjects were running on a treadmill with plantar pressure sensors. After 6 min of familiarization subjects were asked to run for another 10 min. EMG profiles were recorded at m. gastrocnemius med. (GM) and lat. (GL), plus m. soleus (SL). The steps were separated based on the ground reaction forces and the mean of 30 steps was calculated. Amplitude was normalized by the mean activation within a stride and data were time normalized to 100% of a step. Subtalar joint orientation was estimated using an inertial measurement unit-based system validated recently (3). EMG profiles were separated into two groups using feature extraction, feature reduction with principal

component analysis and k-means clustering. Correlation between the 3 main components to the joint axis was calculated. Significant differences between the group means were calculated using an independent T-test.

#### RESULTS:

The k-means algorithm separated two groups based on the EMG data. The main feature was the simple squared integral of each muscle. The joint axes between the groups were significantly different. Correlation with the main feature SSI of GL  $r=.47$ , SSI of GM  $r=-.32$  and of SL  $r=.10$ .

#### CONCLUSION:

This study showed for the first time a relationship between specific muscle activation parameters and the orientation of the subtalar joint axis. Nearly 50% of the variance in the joint axes results was solved by the muscle activation. Significant different groups were built by the k-means algorithm. The negative correlation with the GM supports the results from previous work (4), where a twisted Achilles tendon is discussed. A limitation of the study is the small sample size. Another limitation is the joint axis estimation. As it assumes a single degree of freedom joint the inferred joint axis can be seen as a rough estimation.

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## EFFECTS OF A POST-ACTIVATION POTENTIATION PROTOCOL ON JUMPING BIOMECHANICAL VARIABLES IN COLLECTIVE SPORTS PLAYERS

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#### INTRODUCTION:

Post-Activation Potentiation (PAP) is a physiological phenomenon that enhances physical performance such as jumping ability(1). Vertical jumping and the biomechanical variables associated are relevant for collective sports(2). In that sense, understanding how PAP could modify biomechanical jump variables could be feasible to comprise the effects on jumping performance. For that reason, the aim of this study was to determine maximal output load effectiveness as a PAP on countermovement jump biomechanical variables after executing half-squat exercise in collective sports players.

#### METHODS:

The study comprised twelve basketball and soccer players (age:  $22.3 \pm 3,7$  years; height:  $175.1 \pm 5.6$  cm; weight:  $73.6 \pm 13.8$  kg) which performed 2 sessions. In the first one, athletes executed a squat incremental test to determine maximal concentric power during half-squat (SmartCoach Power Encoder; Stockholm, Sweden). In the second session, participants performed a standardized warm-up based on 5 minutes jogging and 2 sets of 10 repetitions bodyweight squat. After that, participants performed 3 countermovement jumps (CMJ) on a force plate (Accupower; AMTI, Watertown, MA). After a suitable rest, the participants performed 6 repetitions of half squat with maximal concentric power load. Finally, athletes performed 3 CMJ on the same force plate. Force-time data was analysed following impulse-momentum method(3). The biomechanical parameters analysed were: jump height, upward displacement, maximum downward and upward velocity, total time, downward and upward movement time. Statistical analysis was made using SPSS software (25.0 version). Normality Shapiro-Wilk test, T test for related samples and effect size were conducted for all variables.

#### RESULTS:

Total time (before PAP:  $0.95 \pm 0.18$  and after PAP:  $0.82 \pm 0.1$ ) and downward time (before PAP:  $0.66 \pm 0.17$  and after PAP:  $0.54 \pm 0.07$ ) were significantly lower after PAP ( $p<0.05$ ) and the effect size was moderate. The study did not find differences in jump height, velocity and displacement variables.

#### CONCLUSION:

The present study showed a reduction in jump time execution due to a decrease in downward time and did not found differences in the other biomechanical parameters. These outcomes show that PAP could increase the jumping ability reducing the time that athletes need to reach the same jump height.

Finally, this work exposes that collective sports players might decrease the jump execution time, achieving same jump height. This finding could be considered an advantage against competitors.

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## THE BIOMECHANICAL DIFFERENCES ASSOCIATED WITH THREE METHODS OF LOAD CARRIAGE AND THEIR RELATIONSHIP TO ECONOMY

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UNIVERSITY OF HUDDERSFIELD

#### INTRODUCTION:

Energy saving phenomena have been reported with loads carried on the head (1), back (2) and distributed between the back and front (back/front) (3). Research has attempted to identify explanatory mechanisms (4, 5), yet the determinants remain unclear. We have identified individual variation in economy (5, 6) and altered gait characteristics (6) across loads carried on the head, back and back/front. This study aimed to explore relationships between economy and biomechanical changes associated with head, back and back/front load carriage.

#### METHODS:

Fifteen volunteers (10 males, 5 females; age =  $25 \pm 3$  years; stature =  $1.78 \pm 0.07$  m; body mass =  $73.6 \pm 10.1$  kg) completed three trials that differed by load carriage method (back (B), head (H) and back/front (BF)), in a randomised order. Each trial involved walking on a force-instrumented treadmill at 3km/h with 0, 3, 12 and 20 kg. Walking periods lasted 4 mins, separated by 2 mins rest. Expired gas was analysed continuously. 3D motion capture was employed to analyse the walking gait. Outcome measures included load carriage economy (ELI), step



parameters, peak joint angles and ground reaction forces. Two-way repeated measures ANOVAs between load carriage conditions were performed. Relationships were assessed using Pearson's correlation coefficients.

**RESULTS:**

ELI values indicated significantly worse economy for H compared to B and BF ( $P=0.01$ ). H was associated with significantly increased step length ( $P=0.03$ ), decreased cadence ( $P=0.01$ ), and increased trunk ( $P=0.01$ ) and hip ( $P=0.01$ ) extension compared to B and BF. The  $\Delta$  2nd peak of vertical force (N/kg) from unloaded walking (UW) was smaller for BF than for H and B ( $P=0.01$ ). ELI significantly correlated with  $\Delta$  cadence ( $r=0.580$ ,  $P=0.02$ ),  $\Delta$  step length ( $r=-0.650$ ,  $P=0.01$ ) and  $\Delta$  trunk angle range of motion (ROM) ( $r=-0.560$ ,  $P=0.03$ ) from UW with H 12kg. ELI for BF 20kg was significantly correlated with  $\Delta$  maximum ( $r=0.578$ ,  $P=0.02$ ) and  $\Delta$  minimum ( $r=0.535$ ,  $P=0.04$ ) sagittal plane trunk angles from UW, and the 2nd peak of vertical force ( $r=-0.600$ ,  $P=0.02$ ) from UW.

**CONCLUSION:**

H was associated with worse economy and a more upright posture compared to B and BF. Increased cadence, decreased step length and a reduced trunk ROM, were associated with improved economy with H at 12kg. Shorter stride lengths may improve economy and stability with vertical loading through reduced vertical oscillations of both the centre of mass and the added load (5). It's possible that this, combined with decreased trunk ROM may improve economy for head-loading. The relationship between larger peak flexion and extension of the trunk and improved economy in BF20kg supports the theory that increased freedom of movement in the trunk with heavy loads may improve economy for BF compared to back-loading methods (3).

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**THE EFFECT OF CHANGING CENTER OF PRESSURE ON REARFOOT IN/EVERSION DURING TREADMILL RUNNING**

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UNIVERSITY OF GRONINGEN

**INTRODUCTION:**

Atypical rearfoot eversion and medial longitudinal arch angle (MLAA) are important kinematic risk factors for running-related injuries [1,2]. Prominent intervention options for atypical rearfoot eversion and MLAA include foot orthoses, footwear, and taping; yet a running gait retraining is lacking. The COP is considered to be associated with biomechanical alterations in the lower-limb joints; previous studies highlighted the high potential of the COP manipulation into altering gait characteristics, joint biomechanics, and modifying foot malalignment [3,4]. This suggests that changes in mediolateral COP during running may have the potential to change rearfoot in/eversion. The aim was, therefore, to investigate changes in rearfoot in/eversion, subtalar pronation, and MLAA while shifting the center of pressure (COP) toward the lateral and medial side of the foot during running.

**METHODS:**

Fifteen healthy female runners underwent gait analysis in 3 conditions: normal running, running on lateral (COP lateral) and medial (COP medial) side of the foot. Foot progression angle was controlled using real-time visual feedback. COP was calculated relative to foot using force plate data. Five steps were analyzed for each task. To select steps for lateral and medial COP conditions, the first 5 steps whose mediolateral COP value were 5mm smaller (for medial) or larger (for lateral) than baseline averaged mediolateral COP were selected. Ground reaction force (GRF) data were used to identify the stance phase. Main outcomes were 3D kinematics of rearfoot in/eversion, subtalar supination/pronation, and MLAA, FPA, and GRF were analyzed. A repeated-measures ANOVA followed by pairwise comparisons was used to analyze changes in outcome between three conditions.

**RESULTS:**

Running on the lateral side of the foot compared to normal running and running on the medial side of the foot reduced peak rearfoot eversion (mean difference (MD) with normal=3.3°;  $p<0.001$ , MD with COP medial=6°;  $p<0.001$ ), peak pronation (MD with normal=5°;  $p<0.001$ , MD with COP medial=9.6°;  $p<0.001$ ), and peak MLAA (MD with normal=2.3°;  $p<0.001$ , MD with COP medial=4.1°;  $p<0.001$ ). Running on the medial side of the foot significantly increased these kinematic factors compared to normal running and running on the lateral side of the foot.

**CONCLUSION:**

The present study demonstrated that translation of COP along the mediolateral foot axis has a significant effect on rearfoot eversion, MLAA, and subtalar pronation during running. Running with either more lateral or medial COP reduced or increased peak rearfoot eversion, peak subtalar pronation and peak MLAA, respectively, compared to normal running.

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**BIOMECHANICAL STUDY ON THE INFLUENCE OF DIFFERENT LOADS ON THE GAIT CHARACTERISTICS OF UPHILL WALKING**

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**INTRODUCTION:**

Weight-bearing walking is a common way of life and training. Different weight load can change the gait characteristics of human body. However, in the uphill walking, the influence of different loads on human gait is not clear. Gait features include space-time index, kinematics index and dynamics index. From the perspective of mechanics and time, this study compares the effects of different body loads on the gait of the human body in the uphill walking.

**METHODS:**

10 male subjects were selected. Age range: 23-26 years old; height:  $176.6 \pm 5.0$ cm; weight:  $71 \pm 8.3$ kg. The load weight is no load, 15kg and 30kg respectively. The load was put on the subjects in the form of weight-bearing vests, and the weight was evenly distributed in front,

back, left and right of the subjects, the test was carried out on a treadmill with a walking speed of 4km/h, the angle of the treadmill is 8 degrees. The gait indexes were collected by the pedar-x plantar pressure test system (including peak plantar force, peak plantar pressure, maximum contact area between sole and ground, impulse of one-step, support phase time and a complete one-step time). SPSS 22.0 was used to process the analysis data, and nonparametric test was used to compare the differences of each index under different load.

#### RESULTS:

In the uphill state, with the increase of load, the peak foot pressure and the impulse increased, and there was a very significant difference (peak force, no load:  $683.6 \pm 110.2\text{N}$ , 15kg load:  $800.1 \pm 118.7\text{N}$ , 30kg load:  $916.6 \pm 134.8\text{N}$ ,  $P = 0.005$ ; peak impulse, no load:  $299.3 \pm 66.4\text{Ns}$ , 15kg load:  $360.2 \pm 64.5\text{Ns}$ , 30kg load:  $408.9 \pm 72.5\text{Ns}$ ,  $P = 0.009$ ). Plantar pressure also increased significantly, but the difference was relatively small (peak pressure, no load:  $267.0 \pm 83.1\text{kPa}$ , 15kg load:  $320.6 \pm 97.3\text{kPa}$ , 30kg load:  $341.8 \pm 79.2\text{kPa}$ ,  $P = 0.041$ ). The maximum contact area between the foot and the ground increases with the increase of load, but the difference is not significant (maximum contact area, no load:  $109.3 \pm 23.6\text{cm}^2$ , 15kg load:  $119.6 \pm 18.1\text{cm}^2$ , 30kg load:  $125.2 \pm 18.5\text{cm}^2$ ,  $P = 0.159$ ). There was no significant difference in the support phase time and single step gait cycle time (support time, no load:  $0.672 \pm 0.057\text{s}$ , 15kg load:  $0.675 \pm 0.051\text{s}$ , 30kg load:  $0.677 \pm 0.077\text{s}$ ,  $P = 0.993$ ; gait cycle time, no load:  $1.107 \pm 0.082\text{s}$ , 15kg load:  $1.084 \pm 0.080\text{s}$ , 30kg load:  $1.048 \pm 0.094\text{s}$ ,  $P = 0.257$ ).

#### CONCLUSION:

1) In the uphill state, the increase of load will lead to the significant increase of foot pressure peak, pressure peak and impulse. 2) Because of the increase of the contact area between the foot and the ground, the rate of increase of the peak pressure of the foot is relatively small. 3) Weight bearing does not change the gait time index when going uphill.

## OP-BM03 Motor control

### OVER TIME EFFECTS OF MENTAL FATIGUE ON SPEED-ACCURACY TRADE-OFF

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#### INTRODUCTION:

Mental fatigue (MF) is defined as a psychobiological state caused by prolonged periods of demanding cognitive activity and characterized by subjective feelings of "tiredness" and "lack of energy" (Boksem and Tops, 2008). MF can have many effects on physical performances (for a review see Pageaux and Lepers, 2018). Among the negative effects, Rozand et al. (2015) reported an alteration of motor control after 90 min of Stroop task evidenced by an increase in arm pointing movement duration. Even though the effects of MF on motor performances have been well documented, the recovery of MF has received little attention. The present study, which used electroencephalography (EEG), aimed (i) to evidence electrophysiological markers of MF, and (ii) to examine the recovery of MF by combining behavioral, subjective, and electrophysiological measures.

#### METHODS:

Fifteen participants completed 32 min of the Time Load Dual Back (TLDB) task, a cognitively demanding task known to induce MF. Before (pre), immediately after (post), 10 min after (post10) and 20 min after (post20) the TLDB task, participants performed an arm movement, consisting in pointing to a target as fast and as accurately as possible. Before each arm pointing task, participants reported their level of MF on a visual analogue scale (VAS) and brain oscillations were recorded for 2 min. To evaluate MF effects, pretest and posttest were compared whereas recovery effects were analysed comparing post, post10 and post20 measurements.

#### RESULTS:

MF feeling increased after the TLDB task ( $p < .001$ ). EEG analysis showed that alpha power ( $p = .018$ ) and beta power ( $p = .041$ ) also increased after the TLDB task. Pointing performances were not altered immediately after the TLDB task. During the recovery period, MF feeling decreased over time ( $p < .001$ ) but remained higher in post20 compared to pre values ( $p < .001$ ). In contrast, pointing movement duration increased during the 20-min recovery period ( $p = .020$ ).

#### CONCLUSION:

MF was successfully induced by the TLDB task, as illustrated by the increase in MF feeling and in alpha power. Contrary to previous studies (e.g. Rozand et al., 2015), no deterioration of behavioral performance (i.e., pointing movement duration) was observed after the TLDB task. During the 20-min recovery period following TLDB task, even if feeling of fatigue decreased, the participants did not fully recover and some alterations of motor control were present. These results suggest that subjective, behavioral and electrophysiological measures might lead to different but complementary cues about mental fatigue state.

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### A VIRTUAL REALITY OBSTACLE AVOIDANCE TASK LEADS TO LIMB-SPECIFIC LOCOMOTOR ADAPTATIONS BUT NOT INTER-LIMB TRANSFER

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#### INTRODUCTION:

For the training of human balance and gait control, simulation techniques such as virtual reality (VR) are being used increasingly (1). A virtual environment can provide safe but also challenging training conditions and controlled stimulus delivery. Importantly, VR can reduce the requirement for training equipment and may provide more realistic training scenarios. This study examined i) adaptation of gait stability in a VR task in which young adults were repeatedly required to avoid virtual obstacles and ii) transfer of gait adaptation from the trained to the untrained leg.

#### METHODS:

Twelve healthy young adults ( $21.5 \pm 1.5$  yrs) took part in a VR obstacle avoidance training. Participants walked on a treadmill whilst wearing a VR headset and with their body state represented by an avatar in VR. Movement kinematics were tracked using a motion capture system (120 Hz, Qualisys, Gothenburg, Sweden) and synchronized with the VR system. During walking, virtual obstacles appeared unexpectedly in front of the participants over randomized time spans with respect to the individual's gait cycle. After crossing 50 virtual obstacles with their

right leg, participants had to cross one unexpected obstacle with the left leg (interlimb transfer). The anteroposterior margin of stability (MoS) was calculated as the difference between the anterior boundary of the base of support and the extrapolated center of mass at foot touchdown (TD) (2). In order to study motor adaptation to repeated practice, we pooled obstacles 1-3 for early, obstacles 24-26 for mid and obstacles 48-50 for late adaptation.

**RESULTS:**

Crossing virtual obstacles resulted in an increased MoS at TD (i.e. a more stable body configuration) over repeated practice, determined between the early (mean and SD:  $5.0 \pm 2.1$  cm) and mid ( $6.9 \pm 2.1$  cm) as well as late ( $7.9 \pm 1.8$  cm) adaptation phases ( $P < 0.05$ ), but with no significant difference between mid and late. Comparison of MoS values in the early phase of the trained leg with the trial of the untrained crossing leg revealed no statistically significant difference (average MoS at TD of the untrained left leg  $\sim 5$  cm).

**CONCLUSION:**

Our findings revealed that repeated practice of obstacle avoidance using VR as a training tool can stimulate adaptive improvements in gait stability in crossing an obstacle during treadmill walking. The similar learning curve to previous mechanical gait interventions supports the view that VR may be an alternative method to train locomotor balance components in a safe and controlled environment. The VR obstacle avoidance task led to robust adaptations to stability control but, in contrast to our expectations, no inter-limb transfer of locomotor adaptation was observed. Any generalizability from leg to leg appears to be quite limited.

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**DECREASED CONTRIBUTION OF LEG MUSCLE PROPRIOCEPTION IN POSTURAL CONTROL WITH AGEING**

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**INTRODUCTION:**

One important component of postural control, i.e. the capacity to maintain upright standing, is the ability to detect body sway, which mainly arises from leg muscle spindles in steady upright standing (1). Even though a line of evidence indicates that ageing is associated with a decreased contribution of the proprioceptive signal from muscle spindles in postural control (2), no clear-cut conclusion can be drawn on this issue. To step further in this topic, we assessed the aftereffects of prolonged vibration of the Achilles tendons on postural control in young and older adults. We hypothesized that a decreased contribution of muscle proprioception in postural control, as expected in older adults, should be associated with lesser vibration aftereffects on balance.

**METHODS:**

Fifteen young ( $23 \pm 2$  yr) and fifteen older adults ( $68 \pm 6$  yr) participated in Experiment 1, which consisted of recording the mean position of the centre of pressure (CoP), CoP path length, CoP velocity, before and after vibrations (100 Hz) applied simultaneously in both Achilles tendons during 1h in seated posture, aimed at depressing the proprioceptive signal from leg muscle spindles (3). To confirm that the efficacy of tendon vibration to depress the muscle spindle pathway was similar between young and older adults, we recorded the Hoffmann (H) reflexes and Mmax in soleus (SOL) muscle in seated posture in eight young ( $24 \pm 2$  yr) and eight older ( $67 \pm 6$  yr) adults (Experiment 2). The vibration procedure in Experiment 2 was similar to those used in Experiment 1.

**RESULTS:**

After the 1-h vibration, the mean CoP position shifted forward in both groups ( $p < 0.05$ ), with a greater magnitude of change in young ( $74 \pm 41\%$ ) than older adults ( $44 \pm 40\%$ ;  $p < 0.05$ ). The other CoP parameters only increased in young adults after vibration ( $p < 0.05$ ) (Experiment 1). The H-reflex amplitude decreased similarly ( $p > 0.05$ ) in young (before:  $47 \pm 12\%$  Mmax; after:  $28 \pm 17\%$  Mmax) and older adults (before:  $34 \pm 13\%$  Mmax; after:  $21 \pm 14\%$  Mmax) in seated posture (Experiment 2).

**CONCLUSION:**

The results highlight reduced aftereffects of prolonged Achilles tendon vibration on postural control in older adults. In contrast, Achilles tendon vibration performed in seated position decreased to the same extent the H-reflex amplitude in young and older adults, indicating that the vibration procedure altered similarly the muscle spindle pathway in both groups. These results indicate an age-related decrease in the contribution of leg muscle proprioception in postural control with ageing.

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**OP-BM05 Knee, ACL and Hamstring****IS EMG-FORCE RELATIONSHIP OF A SINGLE REGION SIMILAR TO THAT ASSESSED FROM SEVERAL REGIONS WITHIN THE INDIVIDUAL HAMSTRING MUSCLES?**

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**INTRODUCTION:**

The relationship between the electromyographic (EMG) activity and the performed force provides a better understanding of neuromuscular activation property of skeletal muscle. Recent researchers suggest that EMG activity is different depending on the evaluated region of the biceps femoris long head (BFh) and semitendinosus (ST) (1, 2). This implies that the EMG-force relationship may be inconsistent among regions within the hamstring muscles. However, the EMG-force relationships of BFh and ST have been only evaluated from a single region (i.e., 50% of thigh length) in previous studies (3, 4, 5). Thus, it remains unknown whether the EMG-force relationship varies according to the evaluated region of the hamstring muscles. Furthermore, the EMG-force relationship of a single region may be dissimilar to that of whole muscle assessed from several regions if the regional difference in EMG activity is observed within a muscle. Despite this possibility, no study directly compared the EMG-force relationship between EMG recording processes (i.e., recording from a single region or several regions). Therefore, the aims of this study were 1) to clarify whether the EMG-force relationship differs depending on the evaluated region of the individual hamstring muscles and 2) to compare the EMG-force relationship of a single region with that of the whole muscle.

**METHODS:**

Thirteen healthy men performed isometric knee flexion at 20%–100% of maximal voluntary contraction (MVC) at 30° of knee flexion. Surface EMG activities in the proximal, middle, and distal regions of BFlh, ST, and semimembranosus (SM) were assessed and normalized to the root mean square (RMS) during MVC as %RMS. The %RMS in the three regions of each muscle were averaged and compared with that of the middle region at each torque level.

**RESULTS:**

The result showed that %RMS of BFlh was consistently higher in the distal regions than in the proximal region at 20%–80% of MVC ( $p < 0.05$ ). The %RMS of SM was higher in the middle region than in the proximal region at 20% and 40% of MVC ( $p < 0.05$ ). Meanwhile, no difference in %RMS was observed between two EMG recording processes (i.e., recording from the middle region or several regions) across all torque levels in the individual hamstring muscles.

**CONCLUSION:**

The results suggest that the EMG-force relationship is distinctly different between regions of BFlh, but the difference in EMG recording processes has little effect on the EMG-force relationship of the individual hamstring muscles. Specifically, the EMG-force relationship of the middle region would be similar to that of whole muscle in all hamstring muscles. This would be practical information on the surface electrode placement of the hamstring muscles.

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### **LOCAL-VIBRATION TRAINING-INDUCED IMPROVEMENT OF QUADRICEPS STRENGTH RECOVERY EARLY AFTER ACL RECONSTRUCTION**

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**INTRODUCTION:**

In the first weeks after anterior cruciate ligament reconstruction (ACLR), patients present large quadriceps strength deficits with quadriceps activation failure acknowledged to be a substantial contributor [1]. Reactivating quadriceps is therefore the first aim of early rehabilitation [2]. While the immediate post-surgery context (e.g. pain) hinders optimal use of strength training early in the reeducation, vibration therapy, and more especially local vibration (LV) applied to relaxed muscles, may be proposed. LV induces repetitive small changes in muscle length that activate afferents originating from muscle spindles. Prolonged LV exposure at rest induces acute neural modulations, and when chronically used (i.e. LV training, LVT), it can in turn trigger long-term adaptations [3]. We accordingly demonstrated that four weeks of quadriceps LVT increased muscle strength and neural drive in healthy subjects [4]. In the present study, we tested the hypothesis that LVT during the early post-ACLR period (i.e. ~10 weeks) would improve strength recovery.

**METHODS:**

Thirty patients attending ACLR were randomized without any blinding into two groups (vibration: standardized rehabilitation plus LVT,  $n=16$ ; or control: standardized rehabilitation alone,  $n=14$ ) group. Both groups were evaluated before surgery (PRE) and after (POST) receiving 24 sessions of standardized rehabilitation over ~10 weeks after surgery. Patients of the vibration group received one hour of vibration applied to the relaxed quadriceps of the injured leg at the end of each rehabilitation session. Primary outcome was maximal isometric strength of both injured and non-injured legs (i.e. allowing for limb asymmetry measurement). Secondary outcomes were rate of force development (RFD) as well as measures of functional performance, i.e. Timed Up and Go test (TUG) and Six-Minute Walk Test (6MWT).

**RESULTS:**

Seven patients were lost to follow-up. For the injured leg, the mean decrease in maximal strength from PRE to POST was significantly lower for the vibration group ( $n=11$ ,  $-16\pm 10\%$ ) than for the control ( $n=12$ ,  $-30\pm 11\%$ ) group ( $p=0.0045$ ). Mean PRE–POST changes in limb symmetry was lower for the vibration ( $-19\pm 11\%$ ) than the control ( $-29\pm 13\%$ ) group although not reaching the level of significance ( $p=0.051$ ). Although RFD did not differ between groups and across time, limb symmetry was significantly decreased from PRE to POST in the control group ( $p<0.001$ ) but not in the vibration group ( $p=0.13$ ). No changes in TUG nor 6MWT were observed.

**CONCLUSION:**

The present results demonstrate that LVT improves strength recovery after ACLR. This feasibility study suggests that LVT on relaxed muscles is a promising modality of vibration therapy that could be implemented in the early period of ACLR rehabilitation.

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### **COMPARISON OF BLOOD FLOW RESTRICTION VS. HEAVY LOAD RESISTANCE TRAINING DURING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION PATIENT REHABILITATION: A UK NHS RANDOMISED CONTROLLED TRIAL**

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**INTRODUCTION:**

Low intensity blood flow restriction resistance training (BFRRT) may be an effective and feasible alternative to traditional heavy load resistance training (HLRT) for the rehabilitation of anterior cruciate ligament reconstruction (ACLR) patients. The aim of this study was to compare the effectiveness of BFRRT and standard care HLRT at improving skeletal muscle hypertrophy, strength and physical function in ACLR patients following surgery within the National Health Service (NHS).

**METHODS:**

Twenty-eight patients scheduled for unilateral ACLR surgery with hamstring autograft were recruited for this parallel group single assessor blinded randomised controlled clinical trial. Participants were block randomised to either HLRT at 70% of one repetition maximum (1RM) (n=14) or BFRRT (n=14) at 30% 1RM and completed 8 weeks of biweekly unilateral leg press training alongside standard hospital rehabilitation. Interventions were designed consistent with recommended protocols. Maximal isotonic strength (10RM), muscle morphology of the vastus lateralis of the injured limb, self-reported function, Y-balance test performance, knee joint pain and effusion and range of motion (ROM) were assessed at pre-surgery, post-surgery, mid-training and post-training. Knee joint laxity and maximal isokinetic knee extension and flexion strength at 60°/s, 150°/s and 300°/s were measured at pre-surgery and post-training.

**RESULTS:**

Twenty-four participants completed the study and there were no adverse events. 10RM strength significantly increased in the injured limb (106% for HLRT and 104% for BFRRT) with no group differences. Significantly greater attenuation of knee extensor peak torque loss at 150°/s and 300°/s and knee flexor torque loss at all speeds was observed with BFRRT. No group differences in knee extensor peak torque loss were found at 60°/s. Significant and comparable increases in muscle thickness (5.8% and 6.7%) and pennation angle (3.4 and 4.1%) were observed with BFRRT and HLRT, respectively, with no group differences. No significant changes in fascicle length were observed. Significantly greater and clinically important increases in several measures of self-reported function (50-218% vs. 35-152%), Y-balance performance (18-59% vs. 18-33%), range of motion (78% vs. 48%), and reductions in knee joint pain (67% vs. 39%) and effusion (6% vs. 2%) were observed with BFRRT compared to HLRT, respectively. Knee laxity decreased from pre-surgery to post-training with no group differences.

**CONCLUSION:**

BFRRT can improve physical function, pain and effusion to a greater extent than HLRT while driving similar improvements in muscle strength and hypertrophy. Therefore, BFRRT may be more appropriate for early rehabilitation in ACLR patient populations within the NHS.

**STANDARDIZING MECHANICAL WORK DURING HAMSTRING ECCENTRIC TRAINING: NORDIC HAMSTRING VS. ISOKINETIC EXERCISE**

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**INTRODUCTION:**

The high prevalence of hamstring injury in sport [1] encourages the search for optimal training interventions to maximize muscle and tendon adaptations [2]. Although the Nordic Hamstring (NH) and isokinetic (IK) knee extension exercises are often used in research training protocols, normalization of the mechanical stimulus (i.e. mechanical work and velocity) has rarely been addressed [3]. Accordingly, this study aimed (i) to examine the validity of standardizing mechanical work and knee angular velocity during an eccentric resistance training program comprising NH and IK exercise; (ii) to describe the time-course of changes in torque induced by the two training modalities throughout the intervention.

**METHODS:**

Twenty-seven injury-free males participated in a 15-session training intervention comprising NH (n=13) or IK (n=14) eccentric exercise. The number of sets and repetitions of the NH intervention progressed from 3 sets of 5 repetitions (session 1) to 6 sets of 8 repetitions (from session 12). Mechanical work, computed as the area under the knee torque-angle relationship, and knee angular velocity were computed during each NH repetition from torque and 2D kinematic measures. For each session, the IK training group completed the same number of sets as the NH group matched for mechanical work (Wset), angular velocity and range of motion [4].

Statistical parametric mapping (SPM) curve analyses were employed to evaluate differences in torque and velocity over knee extension. Independent t-tests and Bland-Altman plots were used to evaluate the validity of the standardization procedure.

**RESULTS:**

The IK group showed progressive increments in torque throughout the training intervention at the last third of the time-normalized torque curves. The amount of mechanical work performed per repetition was significantly lower in IK compared to the NH group (124±32 vs. 186±40 J; p<0.001) while Wset did not significantly differ between groups (NH: 1256±410, IK: 1233±426 J; p>0.21). The IK group performed on average 3.1 ± 1.6 repetitions per set more than the NH group. Wset and knee angular velocity revealed trivial systematic bias (21.7 J and 0.23 °/s, respectively). Heteroscedasticity was observed in Wset (r<sup>2</sup> = 0.33) due to slightly lower Wset values in the IK group as Wset increased. No heteroscedasticity was observed in angular velocity (r<sup>2</sup><0.01).

**CONCLUSION:**

These results suggest that normalizing angular work and velocity during NH and IK eccentric interventions is a feasible and valid approach. Notwithstanding, biomechanical differences among exercises (i.e. greater lever arm during the NH) may partly explain the lower mechanical work per repetition and the greater number of repetitions achieved in IK training.

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**NOVEL DEVICE TO ASSESS HAMSTRING FUNCTION. A RELIABILITY STUDY.**

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**INTRODUCTION:**

Hamstring strain injury (HSI) is the most prevalent injury in team sport like football or rugby. One of the main risk factors of HSI is the hamstring force capability. Classically, nordic hamstring exercise (NHE) is used to increase hamstring force and prevent or treat HSI. However, this classic exercise does not easily allow for progressive and unilateral training its effectiveness might be questioned given the absence of clear reduction HSI prevalence during the last years. A recent device (The Hamtech, Human Kinematic, Carros, France) allows (i) accurate, progressive and individualized training or rehabilitation of the hamstring, (ii) both unilateral and bilateral movements and (iii) force output measurements for each leg. The aim of the present study is to test the reliability of this new device to assess hamstring force production during isometric and eccentric contractions.

**METHODS:**

After a familiarization session, thirteen men ( $20.7 \pm 1.6$  yr;  $178.1 \pm 4.9$  cm;  $72.1 \pm 6.3$  kg) performed isometric (unilateral) and eccentric (unilateral and bilateral) contractions. Isometric contractions were performed at  $30^\circ$  knee angle ( $0^\circ$ =full extension) and eccentric contractions were achieved over a range of motion of  $90$  to  $30^\circ$  knee angle. Movement constant velocity was controlled with direct visual feedback. All the contractions were achieved during two separated sessions to test inter-session reliability. During each session, measurements were performed twice to test intra-session reliability. Intraclass correlations (ICC) were used to assess the inter- and intra-session reliability.

**RESULTS:**

The results showed a good reliability inter- and intra-sessions of unilateral peak force during isometric [inter-session:  $ICC=0.95(0.82-0.98)$  and intra-session:  $ICC=0.98(0.92-0.99)$ ] and eccentric contractions [inter-session:  $ICC=0.95(0.84-0.98)$  and intra-session:  $ICC=0.99(0.89-1.00)$ ]. During isometric contractions, the rate of force development over the first 200ms was also a reliable measurement [inter-session:  $ICC=0.89(0.64-0.97)$  and intra-session:  $ICC=0.95(0.84-0.99)$ ]. Although results showed a good reliability inter- ( $ICC=0.98(0.95-1.00)$ ) and intra-session  $ICC=0.99(0.97-1.00)$  of the bilateral peak force during eccentric contractions, poor reliability of the knee angle at the bilateral peak force was reported.

**CONCLUSION:**

The present novel device allows reliable measurements of the bi- and unilateral hamstring force production during isometric and eccentric contractions. The Hamtech also allows reliable measurements of the bilateral peak torque during eccentric contractions. However, results reported that the knee angle at the bilateral peak force is not reliable translating a potential force imbalance or different recruitment strategies between the two legs. Based on our results, the use of the unilateral hamstring force to accurately and reliability assess hamstring muscle capacities might be preferred to the classical use of bilateral hamstring force.

## OP-BM06 Muscle and tendon function

### POTENTIATING EFFECTS OF ACCENTUATED ECCENTRIC LOADING ARE MORE LIKELY TO OCCUR FOR STRONGER INDIVIDUALS

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**INTRODUCTION:**

The primary purpose was to evaluate the acute effects of accentuated eccentric loading (AEL) on bench press repetition velocity and power and subsequent perceived effort and soreness. A secondary purpose was to investigate whether an individual's relative strength influenced such effects of AEL.

**METHODS:**

Resistance-trained men ( $n=8$ ) and women ( $n=2$ ) completed 4 sets of 5 bench press repetitions (reps) following four randomly ordered protocols, including AEL and traditional loading (TL) with concentric loads of 50% (AEL50, TL50) and 65% (AEL65, TL65) 1-rep maximum (1-RM). During TL, the eccentric load remained identical to the concentric action, for the entirety of the set. Variable resistance during AEL equaled 120% 1-RM and was produced via weight releasers, which disengaged after the eccentric phase of the first rep and remained off for the remaining reps in the set. Ratings of perceived exertion (RPE) were taken after completion of the session. Perceived soreness was assessed at baseline, 5-min, 24-hours, and 48-hours post-exercise. Due to individual variations in responses to AEL, Hierarchical Linear Modeling was used to evaluate differences between AEL and TL ( $p<0.05$ ).

**RESULTS:**

For the first rep, AEL50 and AEL65 resulted in lower concentric velocity and power, but greater eccentric velocity and power, compared to TL50 and TL65, respectively ( $p<0.05$ ). As an individual's relative strength increased (1RM / body mass), AEL50 resulted in slower eccentric velocity, but faster concentric velocity and greater eccentric power, compared to TL50 ( $p<0.05$ ). Likewise, a relative strength by protocol interaction existed for 65% 1-RM protocols such that, eccentric and concentric power and concentric velocity were increased due to AEL65, compared to TL65, resulting in positive performance responses during AEL65 for the strongest individuals. The change across reps demonstrated a greater increase in concentric velocity and power and eccentric velocity for AEL50 and AEL65 compared to TL50 and TL65, respectively ( $p<0.05$ ). Yet, mean comparisons between conditions revealed trivial increases in concentric velocity from AEL50 compared to TL50, while small effect sizes demonstrated slower concentric velocities during AEL65 than TL65. For RPE, there were no differences between AEL50 and TL50 ( $p=0.125$ ) or AEL 65 and TL65 ( $p=0.196$ ). Post-exercise soreness ratings remained unchanged from baseline ( $1.80 \pm 0.20$  AU;  $p<0.05$ ) and never rose above mild levels (i.e. sore = 3 AU).

**CONCLUSION:**

Overall, AEL with 120% 1-RM was not effective for increasing concentric velocity or power during the bench press with concentric loads of 50% and 65% 1-RM. Yet, stronger individuals may experience increases in concentric performances from AEL, which may be a result of different pacing strategies employed during the eccentric phase. Further, when using the current AEL protocols, eccentric intensities were increased with no greater RPE during exercise or soreness post-exercise.

### INTER-LIMB MECHANICAL PROPERTIES OF THE TRICEPS SURAE MUSCLE-TENDON UNIT IN MASTER SPRINTERS

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LONDON SOUTH BANK UNIVERSITY

**INTRODUCTION:**

Human muscle-tendon units (MTUs) adapt to both ageing and mechanical (un)loading. However, a different time course of adaptation and unequal loading patterns of muscle and tendon may affect MTU's inter-limb uniformity (1), possibly increasing injury risk in older athletes. We examined the triceps surae MTU mechanical properties of healthy young elite sprinters, master sprinters and recreationally active young adults to detect potential changes in the uniformity of adaptation within the triceps surae MTU due to ageing and mechanical loading.

**METHODS:**

Ankle plantarflexion moments and Achilles tendon stiffness of both legs were assessed for three different groups using simultaneous dynamometry and ultrasonography: 10 young elite sprinters (mean age and SD:  $22 \pm 3$  yrs) and 12 master sprinters ( $66 \pm 7$  yrs) competing on national and international level as well as 12 recreationally active young adults ( $24 \pm 2$  yrs), acting as controls. Tendon elongation during the loading phase was assessed by manually digitising the myotendinous junction of the gastrocnemius medialis muscle. Tendon stiffness

was determined subsequently in the linear region of the force-length relationship of the tendon. In order to analyse the inter-limb uniformity of triceps surae MTU, symmetry index for muscle strength and tendon stiffness was formed between the preferred and non-preferred leg (2).

**RESULTS:**

Master sprinters demonstrated lower triceps surae muscle strength (mean of both legs and SD: 2.59±0.78 vs. 4.25±0.88 Nm/kg) and tendon stiffness (582±129 vs. 805±158 N/mm) compared to young elite sprinters ( $P<0.05$ ) and lower muscle strength compared to young controls (3.51±0.41 Nm/kg;  $P<0.05$ ). However, no group differences could be observed for the symmetry indexes of triceps surae muscle strength (master:  $-1.2 \pm 21.7\%$ , elite:  $0.9 \pm 11.5\%$  and control:  $5.0 \pm 12.8\%$ ) and tendon stiffness ( $-6.9 \pm 21.6\%$ ,  $0.6 \pm 15.4\%$  and  $3.1 \pm 13.6\%$  respectively).

**CONCLUSION:**

Considering the reported degeneration in leg extensor muscle strength and tendon stiffness with increasing age (3), our results reveal that aged tendons still appear to be mechanosensitive and hence sustain their integrity to higher functional demands. However, although we found no clear sign for a disturbance in the uniformity within the triceps surae MTU through intense athletics training in young age, the twofold stimulus of ageing and training, in contrast, may lead to non-uniform adaptive changes within the triceps surae MTU independent of the analysed leg, making master sprinters perhaps more vulnerable to injury.

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**EFFECT OF ACTIVATION LEVEL ON SHORTENING-INDUCED FORCE DEPRESSION FOLLOWING A STRETCH-SHORTENING CYCLE**

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UNIVERSITY OF VIENNA

**INTRODUCTION:**

When a skeletal muscle is shortened or stretched, the steady-state isometric force after the dynamic phase is smaller or greater, respectively, than the purely isometric force at the corresponding length. Here we examine the history dependence of muscle action in stretch-shortening cycles (SSC) and pure shortening contractions. The focus of this study was to investigate the effects of the contraction intensity on the muscle performance of the quadriceps femoris.

**METHODS:**

Torque of twenty-seven healthy subjects was measured during and after SSC conditions, pure shortening conditions and isometric reference contractions. The tests were conducted at an isokinetic dynamometer with a fixed velocity (60 °/s) and a fixed range of motion (isometric: 20°, pure shortening: 80°-20°, SSC: 20°-80°-20°). Full extension of the knee was set as 0°. In randomized order different contraction intensities were tested (maximal voluntary contraction (MVC) and 20%, 35% and 50% of MVC triggered through electrical stimulation). To examine the steady-state torque after the movement, ANOVA statistics and post hoc Bonferroni test were used for analysis of differences between the conditions. Partial eta squared was used as effect size.

**RESULTS:**

Torque was reduced for all pure shortening conditions and SCC conditions compared to the isometric reference condition (isometric: 20%:  $17.7 \pm 5.3$  Nm, 35%:  $29.5 \pm 7.6$  Nm, 50%  $38.9 \pm 11.6$  Nm, 100%:  $76.0 \pm 26.5$  Nm; pure shortening: 20%:  $16.5 \pm 5.0$  Nm, 35%:  $26.4 \pm 7.9$  Nm, 50%  $35.4 \pm 13.2$  Nm, 100%:  $73.1 \pm 24.6$  Nm; SSC: 20%:  $14.7 \pm 4.7$  Nm, 35%:  $25.0 \pm 7.1$  Nm, 50%  $32.3 \pm 11.2$  Nm, 100%:  $69.9 \pm 28.1$  Nm).

Significant differences ( $p<0.05$ ) of force depression (FD) were found between the different SSC conditions. FD of 35% and 50% contraction intensity conditions were higher compared to MVC condition (partial eta squared = 0.200). No significant differences were found between the pure shortening conditions.

**CONCLUSION:**

Both the contraction intensity as well as the type of activation (voluntary versus electrical stimulation) seem to have an influence on the steady-state torque after the SSC. However, such a difference was only found for the SSC conditions but not for the pure shortening conditions. Therefore, the difference should be caused by the initial stretch phase.

**COMPARING RATIOS OF HAMSTRINGS AND QUADRICEPS STRENGTH IN RESTED AND FATIGUED CONDITIONS**

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**INTRODUCTION:**

Injury prevention is an important topic in soccer, especially when it comes to knee injuries [2,3]. The relation of peak torque between hamstrings and quadriceps (H-Q) is suggested as a parameter to predict injury risk since decades [1,5]. However, controversial findings have been reported indicating no relationship between H-Q ratio and injury risk. According to Pinto et al. [4] the reason for diverse findings is that data have been collected on rested subjects while injuries mostly occur in fatigued conditions. Therefore, the aim of this study is to compare H-Q ratio between rested and fatigued conditions.

**METHODS:**

A sample of 17 male amateur soccer players (age  $22.3 \pm 2.7$  years; body stature  $1.83 \pm 0.06$  m; body mass  $82.1 \pm 4.3$  kg) were recruited for this study. Participants performed two isokinetic tests on separate days for both legs separately before and after inducing fatigue (ISOMED2000, Ferstl GmbH, Regensburg, Germany). Fatigue was induced by fifteen times 5 s sprinting interspersed by 55 s walking on a non-motorised treadmill (Force 3.0, Woodway, Inc., Waukesha, WI, USA). Parameters analysed were H-Q ratio and lateral deficit of dominant kicking leg and non-dominant kicking leg. The resting period between tests was at least 72 h. Paired t-tests have been used to analyse differences between pre and post fatigue exercises and Pearson correlation to assess associations. Significance was accepted at  $p < 0.05$ .

**RESULTS:**

In a fatigued state significant higher H-Q ratio have been found for both legs (dominant kicking leg:  $68.7 \pm 10.0\%$  vs.  $74.8 \pm 11.3\%$ ; non-dominant kicking leg:  $61.3 \pm 6.3\%$  vs.  $70.1\% \pm 6.8\%$ ; both at  $p < 0.001$ ). Whilst H-Q ratio in the dominant kicking leg was significantly correlated between rested and fatigued condition ( $p < 0.001$ ;  $r = 0.82$ ), such a relationship was not found for non-dominant kicking leg ( $p = 0.115$ ;  $r = 0.41$ ).

**CONCLUSION:**

The primary finding of this study was that H-Q ratio was significantly higher after a fatiguing repeated sprint-exercise, indicating that quadriceps muscle fatigued to a greater extent compared to hamstrings muscles in amateur soccer players. Whilst the H-Q ratio of the dominant kicking leg changes to a predictive extent, this was not true for the non-dominant kicking leg indicating that fatigue does not affect both legs similarly. This could at least partially explain why knee injuries occur in a fatigued state due to different decreases in torque for the dominant kicking and non-dominant kicking leg. Further work is required to establish the process of fatigue applying more sport-specific exercises or fitness level-dependency.

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## **PERFORMANCE ENHANCEMENT IN STRETCH-SHORTENING CYCLES AND ITS RELATION TO RANGE AND SPEED OF MUSCLE ACTION**

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**INTRODUCTION:**

Stretch shortening cycles (SSC) are the most common muscle action in sports or daily locomotion. During the concentric phase of a SSC, muscle force, work and power are increased by up to 50% when compared to pure shortening contractions (Cavagna et al., 1968). Mechanisms related to elastic energy preservation, reflex activity, preactivation or residual force enhancement are discussed (Seiberl et al., 2015). The aim of this study was to better understand the contributions and interplay of the serial elastic and the contractile component of the muscle-tendon-unit (MTU) during SSCs with varying range of motion (ROM) and speed.

**METHODS:**

13 subjects performed submaximal plantar flexion contractions on a dynamometer using electrical nerve stimulation, including isometric, shortening, lengthening and SSC contractions at 60% of individual maximum (velocities: 40 & 120°/s; ROM: 15 & 25°). Additionally, 2 synchronized ultrasound probes and 3D motion capturing were used to track changes in fascicle length of the gastrocnemius medialis and Achilles tendon (AT), and to determine the dynamic AT moment arm. Variables of interest were: torque and muscle force during and after SSCs, work and related length changes in MTU.

**RESULTS:**

Preliminary results (5 subjects) show increased work of SSC compared to concentric contractions (13-29% for different speed and ROM). Stretch peaks were not affected by changes in speed, ROM or contraction type. Forces after SSC were the same for all shortening contractions regardless of speed and range of motion. High velocities and high range of motion led to increased length changes in AT (9-20% for different conditions). Small range of motion as well as faster shortening led to 23-35% decrease in fascicle length changes during muscle shortening. Fascicle length changes were 40-80% larger during pure shortening when compared to the shortening of SSCs.

**CONCLUSION:**

Reduced concentric muscle work during fast contractions was to be expected due to the force-velocity relation (FVR). Preliminary results shows, that the increased work during SSCs compared to pure shortening seems not to be explainable by a greater contribution of AT as length changes - and therefore passive forces returned to the skeletal system - were not different between conditions. During high velocity contractions, smaller fascicle length changes were accompanied by larger tendon displacements. This combination would make sense as MTU length should be unchanged between conditions. Thereby, reduced the shortening of the muscle, what is beneficial regarding FVR but unfavorable regarding the force-length relation. Mechanisms regarding this interplay are in the focus of further investigation.

## **OP-BM07 Muscle and tendon: stretching, stiffness and tendinopathy**

### **NO EFFECT OF SHORT TERM NSAID TREATMENT AS AN ADDITIVE TO REHABILITATION IN EARLY PHASE TENDINOPATHY**

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**INTRODUCTION:**

Recent studies have suggested a higher degree of inflammation in early phase tendon overuse injuries (tendinopathy) when compared to later stage chronic tendinopathy. This implies a possible additive effect of anti-inflammatory treatments when combined with training interventions. Therefore, the purpose of this study was to compare an initial short-term NSAID treatment plus an exercise intervention with the exercise intervention alone in early phase tendinopathy. We hypothesized that NSAIDs in anti-inflammatory doses combined with the exercise intervention is superior to the exercise intervention alone.

**METHODS:**

The study was designed as a double blinded, placebo-controlled, parallel-group study. Seventy sports active individuals with activity related pain in the Achilles tendon and onset of symptoms within 3 months were included. Patients were randomly assigned to 1-week of NSAID (Naproxen 500 mg b.d.) or placebo treatment. Both groups subsequently received 3 months rehabilitation exercise and load management. Outcome measures were performed at baseline, 1-week and 3 months. The primary outcome was the Victorian Institute of Sports Assessment - Achilles questionnaire (VISA-A (range: [0-100])). Secondary outcomes were neovascularization measured by power doppler ultrasound (US), thickness measured by greyscale US, 1-week recall questionnaires on activity (amount and intensity) and pain using the numerical rating scale (NRS (range: [0-10])).

**RESULTS:**

There was a significant increase in VISA-A score ( $14.5 \pm 2.82$ ;  $p < 0.001$ ) and a decrease in NRS during activity ( $-2.3 \pm 0.4$ ;  $p < 0.001$ ) from baseline to 3 months in both groups. From baseline to 1-week follow up we did not find any significant changes in either VISA-A or NRS score. There was a significant decrease in amount of weekly training ( $-2.7 \pm 0.6$  h/week;  $p < 0.001$ ) and amount of high-intensity Achilles loading activities ( $-52.9 \pm 12.2$  minutes/week;  $p < 0.001$ ) from pre-injury to baseline, which persisted throughout the study period with no differences



between the groups. On the ultrasound (US) recordings we did not observe any significant changes on neither the neovascularization nor on the thickness of the tendon.

**CONCLUSION:**

We did not see any effect of Naproxen at 1-week or 3 months follow-up. For both groups we found a significant improvement in clinical outcomes (VISA-A and NRS) during the intervention period, but the participants were still significantly less active at 3 months compared to pre-injury level. We did not observe any effect of the treatment on the US measurements (thickness and neovascularization). In conclusion, we could not see any effect of short term NSAID treatment, but our results suggest a positive effect of the rehabilitation program (including load management and exercise) on clinical outcomes even without any alterations in tendon blood flow or thickness in patients with early tendinopathy.

**REDUCED ECHO INTENSITY OF PATELLAR TENDONS AFTER TOTAL KNEE ARTHROPLASTY IN ELDERLY PATIENTS. A NON-RANDOMIZED CONTROLLED TRIAL OF ALPINE SKIING.**

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**INTRODUCTION:**

Total knee arthroplasty (TKA) is the treatment of choice in patients with end-stage knee osteoarthritis (Kurz et al. 2009). However, using a standard medial parapatellar approach with infrapatellar fat pad resection in TKA, a systematically enlarged patellar tendon (cross-sectional area; +28%) was found in the operated leg (OP) three years post-surgery (Kösters et al. 2015). This tissue hypertrophy was not reflected in mechanical or material tendon properties when compared to the non-operated leg (NOP). Yet side-to-side differences have never been evaluated quantitatively. Hence, this controlled clinical trial was to reanalyze previously assessed ultrasound data to quantify tissue echogenicity and the effects of a guided alpine skiing intervention on this structural-related tendon parameter.

**METHODS:**

Twenty-eight patients (70.2±3.9 yrs) with unilateral TKA were grouped according to skiing skills to an equal-sized intervention (IG; 2.68±1.00 yrs post-surgery) or control group (CG, 2.69±0.82 yrs post-surgery). Skiing consisted of 12 weeks, 2-3 times per week, 3.5 h per session. Knee extension strength, patellar tendon stiffness, strain, Young's modulus, and cross-sectional area were obtained by combining dynamometry with ultrasound-based determination. Luminosity ratio was calculated offline from grayscale echo intensity of the patellar tendon and the overlying subcutaneous fat (ImageJ: 8-bit resolution) in a relaxed (LRrelax) and maximally loaded (LRmax) phase.

**RESULTS:**

At baseline, anthropometric and tendon mechanical and material parameters did not differ between groups. However, a significant leg and loading effect proved a lower luminosity ratio (LRrelax and LRmax) in OP compared to the NOP leg ( $p < .001$ ,  $\eta^2 \geq .64$ ). LRrelax/LRmax did not correlate with patellar tendon stiffness, Young's modulus, or strain ( $r^2 \leq .09$ ;  $p \geq .13$ ). Skiing intervention did not improve indicators of echogenicity, while stiffness increased in the IG by 5.8% and 15.8%, respectively, in the OP and NOP legs. None of the tendon parameters changed in the CG.

**CONCLUSION:**

The homogeneously reduced LR of the whole patellar tendons years after TKA, with no changes in echogenicity after skiing, indicates a profound, long-lasting and irreversible effect of the operation. Although the mechanism responsible for these compositional changes is elusive, we speculate that the resection of the infrapatellar fat pad and thus the blood supply of the tissue (White 2016) affect the proliferation of hydrophilic, non-collagenous matrix components (e.g., proteoglycans, glycosaminoglycans). Interestingly, these changes in tissue composition were not correlated to tendon properties and remain unchanged after skiing training. Further research is needed to uncover the causality of TKA on LR and the mechanism associated with these clinical findings.

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**ACUTE TIME COURSE OF MUSCLE TENDON FUNCTION AND STRUCTURE FOLLOWING DIFFERENT DURATIONS OF STATIC STRETCHING**

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UNIVERSITY OF GRAZ

**INTRODUCTION:**

Depending on the stretching duration and intensity, a single static stretching exercise likely affects muscle function and/or structure immediately after the stretch (1). However, the relationship between static stretching durations and changes in the muscle-tendon-unit (MTU) function and structure several minutes after the stretching exercise is not yet well understood. Therefore, the purpose of this study was to investigate the time course of the changes of the various muscle and tendon mechanical properties (e.g. muscle- and tendon stiffness) and the functional responses (e.g. range of motion (RoM)) of the gastrocnemius medialis (GM) and the Achilles tendon (AT) following 1 min, 3 min, and 5 min of static stretching, respectively.

**METHODS:**

In total, 24 healthy female (mean (SD); 24.4 (2.7) y, 167.1 (4.9) cm, 59.7 (7.0) kg) and 29 healthy male (25.9 (6.2) y, 181.6 (5.7) cm, 75.5 (7.4) kg) volunteered in the study divided into 4 groups, depending on stretch duration: 1) The one-minute static stretching group (SS1; n=11) was tested on four times: before stretching (BS), immediately after stretching (IAS), 20 min after the stretching, and 40 min after the stretching. 2) The three-minute static stretching group (SS3; n=14) was tested BS, IAS, and 5 minutes after stretching. 3) The five-minute stretching group (SS5; n=14) was additionally tested 10 minutes after stretching. 4) The control group (n=14) was tested for baseline values and 10 minutes after the control condition (10min sitting). During each test, the dorsiflexion RoM, passive resistive torque (PRT), and maximum voluntary contraction (MVC) were measured with a dynamometer. Ultrasonography of the GM muscle-tendon junction displacement allowed us to determine length changes in the AT and GM, respectively, and hence to calculate their stiffness. Two-way repeated-measures ANOVA tests or Friedman tests were performed to test for differences between the conditions.

**RESULTS:**

Following the stretching, we observed a significant increase in RoM in all stretching groups (SS1, SS3, SS5) and all measured time points post-stretching (up to 40 min in SS1). MVC decreased only in SS5 at all measured time points (up to 10 minutes). PRT and muscle stiffness was decreased in SS3 and SS5 up to 5 min after stretching but recovered within 10 minutes. Variables in the control group did not change.

CONCLUSION:

The study revealed that already 1 min of static stretching increases RoM for at least 40 min. However, structural changes could only be observed following at least 3min of static stretching. As these changes recovered within 10 minutes after the stretching, the preserved increases in RoM cannot be explained by structural alterations. Hence, we speculate that additional factors, such as increased stretch tolerance (2), affect long-lasting alterations in MTU function and alterations following short stretching durations (1min).

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### **EARLY DEVELOPMENT OF TENDON OVERUSE INJURY (TENDINOPATHY) IN HUMANS: SEQUENCE OF PATHOLOGICAL CHANGES IN STRUCTURE AND TISSUE TURNOVER SIGNALING**

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INTRODUCTION:

Chronic tendon overuse disease (tendinopathy) in sports is associated with increased tendon size, hyper-vascularization, and signs of increased water content secondary to increased amounts of ground substance. However, the sequence of these changes from the early phase of tendinopathy to chronicity is unknown.

METHODS:

In the present study, we examined the early phase of unilateral tendinopathy in both the human Achilles and patellar tendon in sports active individuals (n=200) with initial signs of disease (pain and soreness) in relation to physical activity, and matched with healthy controls (n=50). In a cross-sectional design we investigated patients who had symptoms for either 0-1 month, 1-2 months or 2-3 months, and investigated tendon morphology (US, MRI), mechanical properties (US), tendon vascularization (US) and biomarkers of inflammation, pain, autophagy and regulation of structural proteins from tendon biopsy samples (RT-qPCR), and these findings were correlated with disease duration. We hypothesized that in the early development of tendinopathy a detectable incongruity between matrix protein anabolic and catabolic responses would exist, leading to increased matrix protein signaling, increased tissue degradation signaling, and upregulation of inflammatory activity and angiogenesis. We further hypothesized that this would be followed by an accumulation of connective tissue and edema mediating proteins.

RESULTS:

Tendinopathic Achilles tendon cross sectional area determined by ultrasonography (US) was larger than in healthy control persons. Both Achilles and patella anterior-posterior diameter were elevated in tendinopathy, and only later in Achilles the width was increased. Increased tendon size was accompanied by an increase in hypervascularization (US Doppler flow) in the absence of any change in mRNA for angiogenic factors. From patellar biopsies taken bilaterally, mRNA for most growth factors and tendon components remained unchanged in the tissue of early tendinopathy. However, matrix metalloproteinase 2 (MMP2) was elevated in tendinopathy, and both transforming growth factor (TGF) -beta 1 and substance P were higher in the late vs the very early tendinopathy, whereas markers of cell stress, inflammation, and autophagy remained unchanged. Mechanical properties determined by tendon stiffness remained unaltered over the first 3 months of tendinopathy and similar to the normal contra-lateral tendon.

CONCLUSION:

In conclusion, we observed an early and gradual increase in angiogenesis measured by ultrasound Doppler, in tendon size and in tissue anabolic signaling over the first months of tendinopathy development, whereas no change was observed for passive mechanical tissue properties. Altogether, these findings suggest that tendinopathy pathogenesis represents altered tissue homeostasis by repeated mechanical overloading and inadequate adaptive response rather than disease initiation by a partial rupture of the tendon and disordered repair response.

### **THE ASSOCIATION BETWEEN TAC1, NK-R1, COMT AND SCN9A POLYMORPHISMS WITH PAIN SENSITIVITY AND SELF-REPORTED PAIN IN A SOUTH AFRICAN COHORT WITH CHRONIC ACHILLES TENDINOPATHY: A CASE CONTROL STUDY**

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INTRODUCTION:

The hallmark of Achilles tendinopathy is pain. Pain which, despite years of research, is still not well understood hence it continues to be a challenge to clinicians and athletes. Additionally, tendon pain has large variability in treatment response to available therapies. Research in other chronic pain conditions has shown that some of this variability can be explained genetically. These results show that variants in genes that encode ion channels, neurotransmitters and receptors are associated with pain profiles, analgesic response and chronicity. Such data have helped decipher mechanisms in some of these painful conditions. However, such work has not been conducted in tendinopathy. Perhaps we ought to study tendon pain as any other kind which may provide more information on tendon pain and hence lead us to better treatment paradigms. The objective of the study was thus to study the association between variants in SCN9A, TAC1, TACR1 and COMT and self-reported and experimental pain in a South African cohort of recreational runners with chronic Achilles tendinopathy.

METHODS:

One hundred and fifty three (153) mostly endurance runners completed the short form McGill pain questionnaire (sf-MPQ), short form Brief Pain Inventory (sf-BPI) and the VISA-A questionnaire. Pressure and cold pain were also administered experimentally and conditioned pain modulation (CPM) was assessed. cDNA was extracted from venous blood and genotyped for TAC1 rs2072100; NK-1R rs3771829; COMT rs4818, rs4633 and SCN9A rs6746030 polymorphisms.

RESULTS:

Allele frequency distributions of the variants were similar between cases and controls ( $p > 0.05$ ). TACR1 rs3771829 was associated with CPM. Individuals with the G allele modulated pain better (kPa) [median (IQR)] [69.5 (34.0 – 107.0)] than homozygote individuals (C/C) [38 (3.0- 79.0)] ( $p = 0.036$ ). No associations were observed between pain questionnaire scores and the variants under study ( $p > 0.05$ ).

**CONCLUSION:**

These results are novel in the study of tendon pain and are the first to examine the genetic associations of these common pain gene variants with chronic pain in tendinopathy. The role of TACR1 in mood disorders is well established. Its association with CPM implies that tendon pain has some central and affective mechanisms as seen in other chronic pain conditions. Hence, management of tendon pain should also include psychological paradigms in addition to the physical treatments. More functional work should be conducted to further elucidate the role of these SNPs in the mechanisms of tendon pain.

**REPEATABILITY OF MUSCLE-TENDON UNIT PASSIVE STIFFNESS MEASUREMENTS: MODULATION OF THE CONTRACTILE AND SERIES-ELASTIC ELEMENT**

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**INTRODUCTION:**

Measurements of passive stiffness (PS) are often used to quantify the passive resistance of a muscle-tendon unit (MTU) to stretching, which is interesting in populations who undergo chronic loading and/or excessive stretching through exercise (Moltubakk et al., 2018). This metric may also be used to monitor the 'neuromuscular condition' of a participant taking part in experiments involving multiple visits. However, the repeatability of PS measurements has yet to be established.

**METHODS:**

Twenty-nine participants (10 cyclists, nine triathletes and 10 controls) carried out an ankle PS test on three separate occasions. Testing was carried out on an isokinetic dynamometer (Biodex, USA) throughout each participant's individually determined range of motion (ROM). Passive joint moments at a common angle (5° dorsiflexed) and at individual peak dorsiflexion were measured during slow (10°/s), passive rotation. PS was calculated as the leading edge of a 4th-order polynomial of the moment-angle curve (Moltubakk et al., 2018) at the same locations as passive moment. For a subset of data (n=11), the right gastrocnemius medialis was imaged using a 60 mm linear array ultrasound probe (Telemed, Lithuania) to measure fascicle length change during passive dorsiflexion. This was used to deconstruct the changes in MTU length (Fukunaga et al., 2001; Hawkins & Hull, 1990).

**RESULTS:**

Although ankle ROM showed moderate agreement between the three sessions, passive joint moment showed lower repeatability, both at the common ankle angle and individual peak dorsiflexion. PS at the same locations showed similar repeatability, although these values were more repeatable in the triathletes who showed higher absolute PS values. For the subset of MTU data, both fascicle range and series-elastic element range show poor repeatability between sessions. However, changes in series-elastic element range were associated with a change in passive moment at peak dorsiflexion and ankle ROM (*r*-values: 0.568 – 0.876).

**CONCLUSION:**

The use of a standardised PS test does not show good repeatability across the whole population. Some between-group variation was observed, suggesting this methodology is more repeatable for certain athlete populations. Based on the MTU data, changes in ankle ROM, and thus changes in some PS parameters, are associated with changes in series-elastic element range, but not the contractile element. It remains to be determined whether between-session variation in PS parameters is caused by physiological changes to the MTU or whether the methodology itself is reliable. Investigating group-based and individual differences here could provide further evidence.

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**OP-BM08 Sports biomechanics****JOINT-POWER DISTRIBUTION IN ELITE SPRINT CYCLISTS AND THEIR RELATION WITH MAXIMAL POWER**

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UNIVERSITY OF NANTES

**INTRODUCTION:**

Maximal power (P<sub>max</sub>) is a major determinant of sprint performance in high-level cyclists (Dorel et al., 2005). P<sub>max</sub> at the pedal results from the combination of actions from the three main joints of the lower-limb. Previous studies have described the joint-specific power produced by ankle, knee and hip joints (in extension and flexion) on a road cycling population (Martin & Brown, 2009; McDaniel et al., 2014). However, it is unknown whether the distribution of joint powers is the same in a population of world-class experts and whether it would be related to performance. The aim of this study was to evaluate joint-specific power production in world-class sprinters and to investigate how each joint-power is related to P<sub>max</sub> as well as to the strength capacity of the specific agonist muscle group.

**METHODS:**

22 high-level men sprint cyclists performed a 4-s isokinetic sprint at P<sub>max</sub> (i.e. at optimal velocity, 125 to 135rpm) on a cycle ergometer equipped with instrumented pedals. Motion capture was used to estimate joint power by inverse dynamic. Hence, ankle, knee and hip joint powers were calculated into extension and flexion phases separately. Maximal torque of extensors and flexors of the hip, knee and ankle were measured on an isokinetic ergometer. Simple regressions were used to determine how individual joint powers are related to P<sub>max</sub> and to the maximal torque of the associated muscle groups.

**RESULTS:**

Mean P<sub>max</sub> from one leg was 857W (i.e. 726W in extension and 131W in flexion phase). Ankle extension and flexion power varied from 50 to 242W and -16 to 19W, respectively. Knee extension and flexion power varied from -102 to 254W and 104 to 277W, respectively. Hip extension and flexion power varied from 148 to 488W and -68 to 64W. Only hip extension power was related to P<sub>max</sub> ( $R^2=0.22$ ;  $P<0.05$ ) and only ankle extension power produced during cycling was related to the maximal ankle extension torque ( $R^2=0.46$ ;  $p<0.001$ ).

**CONCLUSION:**

Specific joint power distribution is characterized by a large variability but is fairly in line with values reported for road cyclists (Elmer et al., 2011), except knee flexion which is higher for sprinters (+5%). Interestingly, no relation was observed between knee joint power and both P<sub>max</sub> and knee extensors strength capacity. It would be explained by the key role of bi-articular hamstrings muscles which necessarily

contribute to enhance both hip extension and knee flexion power limiting the net power produced at the knee during the extension phase. Linked with this, an inverse relationship was observed between hip and knee extension powers ( $R^2=0.58$ ;  $p<0.001$ ). On the other hand, the relation between ankle extension power and maximal torque of the plantar flexors suggests that its capacity is crucial and could be a limiting factor in joint power production of proximal muscles. This could also explain why, while hip extension power is the only joint action related with  $P_{max}$ , there are no links with its strength capacity, and so do for others joint actions.

### **IMPACT OF RUNNING AN ULTRAMARATHON ON NEUROMUSCULAR FATIGUE: EFFECTS OF SEX AND DISTANCE.**

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UNIVERSITÉ JEAN MONNET, SAINT ETIENNE

#### **INTRODUCTION:**

Few studies have assessed sex differences in neuromuscular fatigue after prolonged running. Compared to men, women exhibit less peripheral fatigue in plantar flexor muscles (PF) after running a 110-km-mountain-ultramathon [1]. The purpose of the present study was to further characterize sex differences by examining various running distances.

#### **METHODS:**

Thirty-six runners completed the study: 18 men ( $36 \pm 8$  years,  $72.5 \pm 9.6$  kg) and 18 women ( $36 \pm 8$  years,  $59.1 \pm 5.8$  kg). Men and women were matched by relative performance (i.e. percent of winning time of their sex category). Participants completed various races of the Ultra-Trail du Mont-Blanc® ranging from 40 km with 2,300 m of positive elevation change to 170 km with 10,000 m of positive elevation change. One month before the race, participants visited the lab to be familiarized with electrical stimulation on both knee extensor (KE) and PF muscles. Neuromuscular function was tested before and after each race. The testing protocol consisted of a standardized warm-up followed by the assessment of maximal voluntary contractions (MVCs), maximal voluntary activation (superimposed 100 Hz doublet) and contractile properties (potentiated 100 Hz doublet, potentiated 10 Hz doublet and potentiated single twitch (Pt)). For analysis, participants were further subdivided into two groups of 18 runners by distance of race completed (SHORT < 100 km vs LONG  $\geq$  100 km). A factorial ANOVA with deficit (in percentage of PRE value) as a dependent factor and with sex and distance as between-subject factors was used for the analysis.

#### **RESULTS:**

MVC loss was greater after LONG than SHORT in both KE ( $p<0.05$ ) and PF ( $p<0.01$ ) and the decrease in Pt was significantly greater ( $p<0.05$ ) in LONG compared to SHORT in KE, independent of sex. In PF, the decrease in MVC was greater ( $p<0.05$ ) in men than women ( $-35 \pm 11\%$  vs  $-25 \pm 13\%$ , respectively), independent of the distance run. However, women exhibited a greater decrease in Pt compared to men in LONG ( $p<0.05$ ) for PF. Neither sex nor distance effects were observed in maximal voluntary activation for either muscle group.

#### **CONCLUSION:**

The greater muscle strength loss in LONG compared to SHORT fits the previously reported relationship between strength loss and race duration (2). Surprisingly, the present study displayed greater peripheral fatigue in women compared to men after LONG races. However, women lost less muscle strength in PF than men, suggesting that they were globally more resistant to fatigue in plantar flexor muscles.

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### **MUSCLE ACTIVITY AND PERFORMANCE DURING A SUSTAINED ALPINE SKIING SIMULATION**

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UNIVERSITY OF SALZBURG

#### **INTRODUCTION:**

Although alpine skiing is a popular winter activity, many people go skiing on a limited number of days per season. As such, they may not be adequately prepared to manage load during skiing days [1]. While there are a number of studies characterizing biomechanical or physiologic changes between the beginning and the end of a day of alpine skiing [2], the purpose of this study was to investigate changes in electromyographic (EMG) activity during continuous simulated alpine skiing.

#### **METHODS:**

Seven competitive junior ski racers performed a controlled skiing simulation on a ski carpet. The carpet was set to 25% inclination, and 20  $m \cdot s^{-1}$ . Skiers performed turns according to a set tempo corresponding to the typical turn duration for slalom turns ( $\sim 1$  Hz). Participants skied until they could no longer maintain the tempo or until 20 minutes had elapsed ( $\sim 1200$  turns). EMG of the gluteus medius and vastus lateralis was recorded at 2000 Hz. Inertial measurement units attached to the posterior upper cuff of the ski boot recorded three dimensional angular velocities and accelerations at 54 Hz. The turn detection algorithm proposed by Martinez and colleagues [3] was used to detect and segment turns. Mean and standard deviation of turn time and EMG median frequency were calculated for every 2 minutes. A one-way ANOVA was performed to check for differences over time. Alpha level was set to 0.05. All processing and statistics were performed in MATLAB.

#### **RESULTS:**

No changes in turn time were detected during the skiing trial ( $p = 0.912$ ). A main effect of time was observed for both the gluteus medius and vastus lateralis median frequency, where during the early stages (1-4) median frequency was higher than in the later stages (7-10) ( $p < 0.001$ ).

#### **CONCLUSION:**

While this study only included a limited number of participants, and only measured EMG median frequency, the participants in this study altered their skiing technique, at least at the muscle activity level, in order to maintain the turning frequency. While the variable turn time did not change, as expected with a set skiing tempo, there was increased variability as the test progressed, indicating that they had more difficulty maintaining the prescribed turning frequency as the test progressed. The pattern for decreased frequency content with test duration is consistent with previous findings [2], and could provide a useful to manage load during skiing. In conclusion, during simulated alpine skiing on a ski carpet, skiers alter their intramuscular recruitment strategies in order to continue skiing at the set turning frequency.

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### INTERMITTENT PNEUMATIC COMPRESSION EFFECT ON ECCENTRIC EXERCISE-INDUCED STRENGTH LOSS

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#### INTRODUCTION:

Fatigue, which causes reduction of muscle strength, decrease in range of motion, inflammation, muscle pain and appearance of intracellular proteins in the blood, is a sports performance limiting factor. Thus, the recovery of muscular fatigue derived from sports is essential to anticipate athlete's return to training, improving the specific adaptations related to it and reducing the risk of injury. One of the novel techniques used for this purpose is the intermittent pneumatic compression (IPC). When applied on the legs, IPC is able to increase blood flow in the deep veins and enhance systemic fibrinolytic activity. The purpose of our study was to assess the effectiveness of IPC on muscular fatigue recovery following an eccentric exercise bout.

#### METHODS:

A crossover single-blinded study was conducted, in which 12 healthy trained subjects performed four experimental sessions on consecutive days: Day 1 subjects performed one bout of eccentric exercise (10 x10 reps of Drop jumps) to induce muscle injury. The main outcome measure, Countermovement jump (CMJ), was recorded before exercise, and before IPC treatment on each day. The variables measured were flight height, take-off speed and maximum force.

#### RESULTS:

Flight height was higher after the experimental period than the control one (0.290 m vs. 0.266 m at 24h, 0.291 m vs. 0.270 m at 48h, and 0.300 m vs. 0.272 m at 72h). Speed take-off was similar between the two periods, even higher in the control period at 48h (2.257 m/s vs. 2.245 m/s) and at 72h (2.378 m/s vs. 2.324 m/s). Maximum force values were higher after the experimental period (70.61N vs. 67.53N at 24h, 72.89N vs. 68.89N at 48h, and 76.89N vs. 76.19N at 72h). However, no statistically significant results were concluded for any variable.

#### CONCLUSION:

IPC may be an effective alternative for recovering muscle fatigue after sports practice. Nevertheless, the lack of statistically significant results avoids obtaining solid evidence. Thus, further studies with greater sample size and objective measures of muscle recovery as pressure algometry, blood analysis or muscle electromyography should be carried out in order to confirm the efficacy of IPC in early recovery and performance improvement.

### TAKE OFF VELOCITY IN A COUNTER MOVEMENT JUMP AND MUSCLE THICKNESS ARE INDICATORS OF PERFORMANCE IN MASTER CYCLISTS

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#### INTRODUCTION:

Athletic performance decreases with age, and is at least to some extent attributable to a decline in aerobic and anaerobic power (1). It is not clear to what extent the age-related decline in athletic performance is due to concomitant changes in muscle architecture and contractile properties.

#### METHODS:

Sixty-eight participants (52 men (M); 63±11 years and 16 women (W); 50±12 years) were tested at the 2019 World Master Track Cycling Championships. The architecture of the m. vastus lateralis was determined using an ultrasonography device (Siemens ACUSON P500, Erlangen, Germany). Muscle thickness (MT) was defined as the shortest distance between the superficial and deep aponeurosis, penation angle (PA) was the angle between the fascicles and the deeper aponeurosis, and fascicle length (Lf) was measured using the extrapolation method (2). All participants performed a counter movement jump (CMJ) on a force platform (Leonardo Software version 4.2: Novotec Medical GmbH, Pforzheim, Germany). Take off velocity (Voff) was calculated as:  $g \times \text{timeair} / 2$  (3). Data was analysed using SPSS (v.25 IBM). A stepwise regression analysis was performed with the different race times (performance) of 200, 500 and 2000m, with MT, PA, Lf, power (P), force (F), Voff, body mass (BM), age and gender as predictors. Further, stepwise regression analysis of Voff with age, body mass, MT, and F was performed.

#### RESULTS:

Voff was the main predictor of the performance of 200, 500 and 2000m ( $R^2_{adj} = 0.612, 0.692, 0.714$ ). PA was a secondary predictor with a contribution of 8.8%, 6.4% and 3% respectively ( $R^2_{adj} = 0.700, 0.756, 0.791$ ). In the case of the performance of 2000m, age was included in the model with a contribution of 4.7% ( $R^2_{adj} = 0.761$ ). The main predictors of Voff are MT ( $R^2_{adj} = 0.409$ ), with a 18.2% ( $R^2_{adj} = 0.591$ ) contribution of age and 2.8% of F ( $R^2_{adj} = 0.619$ ).

#### CONCLUSION:

These data suggests that the contractile properties of the muscle play a more important role than the force generating capacity for performance of master cyclists. The role of force generating capacity cannot be entirely excluded, as Voff was positively related to MT and F. This suggests that part of the correlation of Voff with performance may be related to muscle strength. To further investigate this contribution, future studies should assess the maximal force generating capacity of the key sport specific locomotor muscles.

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**CORRECTIVE ADJUSTMENTS TO REDUCE THE EFFECTS OF BIOLOGICAL MATURATION IN NEUROMUSCULAR PERFORMANCE**

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**INTRODUCTION:**

Performance evaluation in youth sport is based mostly on chronological age groups, without taking into consideration variations in biological maturation. Such an approach has significant implications in talent identification and selection and in long-term sport participation. In this study we assessed neuromuscular performance of 11 – 16 years male athletes and the purpose was to examine the effects of biological maturation on neuromuscular performance and possible adjustments to control performance for maturity level.

**METHODS:**

429 male athletes competing in soccer, basketball or handball, age ranging from 11 to 16 years performed three countermovement jumps on a force platform. Age groups were formed based on chronological age (CA). Biological status was estimated based on years from peak height velocity (PHV), on bone age (BA) (Sunlight BoneAge) and on morphological age (MA). The latter is a common method in Hungary, used to estimate maturity and is based on growth charts from body size (body weight and body height), and from the body structure indicator (plastic index) by comparing individual values to the developmental status of the Hungarian children of the same age. Linear regression analysis was performed for each chronological age group to examine the effects of maturation on performance, with vertical jump height as the dependent variable and BA or MA as the independent variables. ANOVA was used to compare mean values between early and late matures.

**RESULTS:**

Vertical jump height continuously increased with the increase in either chronological age or biological age. Significant effects of maturation were found only in the 13-year age group for both BA and MA. There were no significant effects for the other age groups. From the regression equation within the 13-year age group the theoretical annual and monthly improvement in performance was calculated. Then, performance in vertical jump was corrected according to the difference (in months) between BA or MA and CA. As expected, before correction significant differences in vertical jump performance were observed between late and early matures (29.9±4.0 vs. 33.4±4.5 cm respectively). Corrective adjustments increased vertical jump performance for late matures and decreased it for early matures, resulting in similar mean values (31.8±4.3 vs. 31.8±4.7 cm respectively).

**CONCLUSION:**

Besides the 13-year age group the lack of effects in the other age groups indicate that within one-year periods vertical jump performance is less sensitive to biological maturation in the 11 – 16 years age range. Biological maturation should be considered mostly around 13 years, which is the age around PHV, when drastic changes are observed in performance. When controlled for maturation differences in performance between early and late matures were removed, thus talent identification could be performed according to individual maturity level, giving a more clear evaluation of the athlete's capabilities.

**OP-BM10 Ageing****INFLUENCE OF A 12-WEEKS RESISTANCE TRAINING PROGRAM ON THE ENERGY COST OF WALKING IN OLDER ADULTS: INSIGHTS FROM MUSCLE- AND JOINT-LEVEL ANALYSES**

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**INTRODUCTION:**

Older adults adopt a preferred slow walking speed that is efficient but reduces their walking performance (1). This is due to impaired mobility resulting from a broad range of age-related declines (2, 3). The realization of strength intervention programs targeting the main muscle groups of the lower limb can effectively reverse age-related deficits (4) with the ultimate goal of improving walking economy and performance. We sought to determine whether a resistance training program reduced the energy cost (Ecost) of walking in older adults and how it influenced the medial gastrocnemius (MG) muscle-tendon and joint dynamics.

**METHODS:**

10 older adults (67.9±2.6 years) performed a 12-weeks resistance training program consisting of seated ankle plantarflexion contractions, seated leg press and knee extension contractions on weight machines three times per week. We estimated Achilles tendon stiffness (ATS), measured plantarflexor strength and muscle architecture of the MG before and after training. We also measured MG fascicle length and velocity, joint moments and Ecost of treadmill walking at 3km/h and 5km/h. T-tests were used for variables estimated during the dynamometer session while two-way repeated measures ANOVA were performed for variables collected during walking.

**RESULTS:**

ATS increased after training (+30%; P=0.0011, large). MG fascicle length (P=0.77) did not change while there was a trend for larger plantarflexor strength (+10%; P=0.066), pennation angle (P=0.066) and muscle thickness (P=0.075) after training. We observed a trend for reduced Ecost of walking after training without significant changes (main effect of time: P=0.11; -4%). Specifically, 7 and 8 participants out of 10 had lower Ecost of walking after training (ranging between -3% to -18% decrease), respectively at 3km/h and 5km/h. Ecost of walking was lower at faster speed (on average -2.8% at 3km/h and -5.4% at 5 km/h). However, we did not find major changes in the interplay between MG fascicle and tendinous tissue nor joint moments at both speeds.

**CONCLUSION:**

A 12-weeks resistance training program can improve walking economy in older adults, especially at fast walking speed. Individual responses highlight reduced Ecost of walking for 70 to 80% of the participants. This was accompanied by a concomitant increase in ATS and to a lesser extent increased plantarflexor strength capacity, and changes in MG architecture. However, these training-related changes did not translate into differences at the MG muscle-tendon or joint level during treadmill walking. Tailored programs combining training interventions and real-time biofeedback during walking (5) may elicit greater biomechanical adaptations in walking (e.g., propulsive power) and further improve walking economy and performance in older adults.

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### AGE-RELATED DIFFERENCES IN THE EFFECT OF PROLONGED VIBRATION ON MAXIMAL AND RAPID FORCE PRODUCTION AND BALANCE ABILITY

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#### INTRODUCTION:

Decreased maximal (Cattagni et al. 2014) and explosive (LaRoche et al. 2010) plantar flexor strength and a deficit in standing balance performance (Cattagni et al. 2014) may increase the risk of falls in older individuals. A previous study (Ushiyama et al. 2005) has shown decreases in maximal plantar flexion strength in young men after prolonged Achilles tendon vibration for 30 min, which was accompanied by the attenuation of the gastrocnemius but not the SOL during contractions. If age-related changes in the function of the three triceps surae have different effects on the plantar flexion strength and balance performance, prolonged vibration would affect the strength and performance differently between young and older adults. We tested a hypothesis that older men would not likely experience deficits in maximal and explosive plantar flexion strength and standing balance performance induced by prolonged Achilles tendon vibration compared with young men.

#### METHODS:

Fifteen older men (73 ± 5 years) and 15 young men (24 ± 4 years) participated in two interventions on different days: quiet spine for 30 min with or without prolonged vibration to the Achilles tendon. The maximal voluntary contraction (MVC) torque during plantar flexion, rate of torque development (RTD), and center of pressure (COP) speed in the anteroposterior direction during single-leg standing were measured. Root mean square of the electromyogram (RMS-EMG) during performance and V-wave and voluntary activation during MVC were assessed.

#### RESULTS:

The MVC torque (7 ± 7%) and RTD (16 ± 15%) of young men but not older men significantly decreased after vibration, and the relative changes observed in the young men positively correlated with changes in RMS-EMG of the medial gastrocnemius (MG) (MVC torque and RTD) and in MG V-wave and voluntary activation (MVC torque). COP speed significantly increased (15 ± 22%) only in the young men and was accompanied by the increased activation of the lateral gastrocnemius.

#### CONCLUSION:

The effects of prolonged Achilles tendon vibration on strength and balance performance were evident only in young men, possibly because of reduced efferent drive. The between-age differences may be related to the attenuated gastrocnemius neuromuscular function in older men.

### EFFECT OF AGING ON NEUROMUSCULAR FATIGUE OF THE KNEE EXTENSOR MUSCLES AFTER AN ISOMETRIC INCREMENTAL FATIGUING TASK

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#### INTRODUCTION:

Aging is characterized by a better resistance to fatigue during sustained isometric tasks. This age-related fatigue resistance may not be relevant for very old adults who are more fatigable than old adults (Justice et al., 2014), and more fatigable than young adults during dynamic tasks (Sundberg et al. (2018). However, fatigability of very old adults and its mechanisms during isometric incremental tasks, involving both low- and high-intensity contractions, remain unknown. The aim of the study was to investigate the effect of old and very old age on neuromuscular performance after an isometric incremental fatiguing test on the knee extensor muscles.

#### METHODS:

Fifteen young (24±3 yr), 10 old (68±4 yr) and 13 very old active men (82±1 yr) performed an isometric incremental quadriceps fatigue test (QIF test) consisting of sets of 10 intermittent contractions (5-s on/5-s off) of the knee extensor muscles, with 10% increase of the maximal force for each set (starting at 10%) until exhaustion. Maximal voluntary force was evaluated before and after the QIF test, as well as voluntary activation (central fatigue) and twitch amplitude (peripheral fatigue) using femoral nerve magnetic stimulation.

#### RESULTS:

Young adults were stronger than old and very old adults (691±94 vs. 518±157 vs. 364±76 N; P<0.001). They all performed a similar number of contractions during the fatiguing task (61±9 vs. 66±4 vs. 62±6 contractions; P=0.39). However, the young adults showed a greater force reduction after the fatiguing task (-30±10%; P<0.001) than old (-21±5%) and very old (-20±8%) adults. Voluntary activation level was reduced with fatigue (Pre: 93±7%, Post: 89±10%; P<0.05) independent of age (P=0.32). Twitch amplitude was greater in young than old and very old men before the test, but very old adults showed less reduction in twitch amplitude after the fatiguing task than the two other groups (-32±22 vs. -29±33 vs. -8±25%; P<0.01).

#### CONCLUSION:

The present results showed that old and very old men were able to perform a similar relative performance than young men during an isometric incremental task. Despite this similar performance, young men had a greater decrease in maximal force production after the fatiguing task than old and very old adults. The greater fatigue was mainly caused by peripheral fatigue, as the decrease in voluntary activation was independent of age. This could be explained by the higher absolute force levels produced by the young adults, and the greater proportion of type II fibers within the muscle of young men compared to old and very old men.

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**OP-MH01 Diabetes, Obesity and metabolic syndrome****OPTIMIZING THE INTERACTION OF EXERCISE VOLUME AND METFORMIN TO INDUCE A CLINICALLY SIGNIFICANT REDUCTION IN METABOLIC SEVERITY**

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**INTRODUCTION:**

Insulin resistance is purported to be a central mediating factor of metabolic syndrome (MetS). Meanwhile, exercise and metformin are proven antidotes to insulin resistance, potentially having additive effects on the alleviation of MetS severity. Evidence also suggests that metformin may blunt the health benefits of exercise. Moreover, the interaction between metformin and different exercise volumes (duration and intensity) and its impact on MetS severity has yet to be investigated. The aim of this study is to therefore explore the impact of a combination of different exercise volumes and metformin on MetS severity.

**METHODS:**

Ninety-nine adults with MetS were randomized into a 16-week exercise program: i) moderate-intensity continuous training (MICT) at 60-70% HRpeak for 30 min/session (n=34, 150 min/week) ii) 4 x 4 min bouts of high-intensity interval training (4HIIT) at 85-95% HRpeak, interspersed with 3 min of active recovery at 50-70% HRpeak (n=34, 38 min/session, 114 min/week); and 1 x 4 min bout of HIIT at 85-95% HRpeak (n=31, 17 min/session, 51 min/week). Metformin intake was monitored and recorded throughout the trial. MetS severity was calculated as z-scores derived from levels of MetS risk factors assessed at pre- and post-intervention.

**RESULTS:**

A total of 65 participants were included in the analysis, of which 18 participants were found to be prescribed metformin. A similar proportion of participants clinically improved MetS severity ( $\Delta \geq 0.60$ ) with (11/18, 61%) or without metformin (30/47, 64%) ( $p=0.84$ ). In those who did not take metformin, there was also a similar proportion of participants who clinically improved MetS severity regardless of exercise volume (MICT, 10/16, 63%; 4HIIT, 10/16, 63%; 1HIIT, 10/15, 67%;  $p=0.96$ ). In those prescribed metformin medication, there was a lower proportion of participants who clinically improved MetS severity following 4HIIT (2/6, 33%) compared to MICT (3/4, 75%) and 1HIIT (6/8, 75%) ( $p=0.23$ ).

**CONCLUSION:**

A clinically significant reduction in MetS severity can be achieved regardless of the exercise volume, with as little as 51 min/week enough to induce a positive change. However, in those prescribed with metformin medication, a higher exercise volume may be contraindicated to elicit a clinically significant change in MetS severity.

**EFFECTS OF POWER TRAINING ON PHYSICAL ACTIVITY, SITTING TIME, DISABILITY AND QUALITY OF LIFE IN OLDER ADULTS WITH TYPE 2 DIABETES DURING THE COVID-19 CONFINEMENT**

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Since the COVID-19 epidemic outbreak, many countries worldwide restricted mobility and social interactions among their citizens as part of their strategies to fight the pandemic. Such approaches are likely to have negative health effects on the general population and even worse in at-risk individuals, like older adults, those with diabetes, respiratory, and cardiovascular disease [1]. Our main goal was to evaluate the impact of a muscle power training program started before and continued during the COVID-19 pandemic on physical activity, sedentary behavior, disability and health-related quality of life (HRQoL) of frail older adults with type 2 diabetes mellitus (T2DM).

Methods: Controlled clinical trial. Thirty-five older adults with T2DM were divided into two groups according to their frailty level (Fried's criteria). Robust participants were allocated in the control group (CG; 73.1 ± 3.9 years; 42.9% male); prefrail or frail participants were allocated to an 11-weeks muscle power training program (6 weeks supervised + 5 weeks unsupervised during mandatory home confinement) (EG; 74.7 ± 4.5 years; 33.3% male). Primary outcomes, including physical activity and sitting time (IPAQ-L), perceived disability (Barthel index), and HRQoL (EQ-5D-3L) were assessed at baseline (pre-confinement, PRE) and after 11 weeks (during confinement, CONF). A two-way repeated-measures analysis of variance (ANOVA) was performed accounting for time and the interaction term between groups and time. Version 25.0 of the SPSS was used for all data analyses. Statistical significance was set at  $p < 0.05$ .

Results: CG reduced a mean of 352.9 minutes and EG reduced a mean of 543.3 minutes of weekly total physical activity during confinement ( $p < 0.05$ ). Thus, sitting time increased by 58% and 32% for CG and EG respectively (time x group interaction  $p < 0.05$ ). Overall, there was no significant time x group interaction in disability and HRQoL measures. However, a nearly significant effect was observed in Barthel scores in EG (from 98.61 ± 2.87 to 100 ± 0.00 Time effect PRE vs CONF  $p = 0.09$ ). It

is relevant to highlight that EG and CG were statistically different at baseline with respect to HRQoL TTO scores (0.937 ± 0.077 vs 0.888 ± 0.066 respectively), but showed similar levels after the training intervention (CONF) (0.898 ± 0.114 vs 0.888 respectively). Conclusion: Muscle power training before and during mandatory COVID-19 self-isolation in frail T2DM older adults: i) softens the COVID-19 domiciliary confinement-related increase in sitting time; ii) Maintains self-reported levels of disability and health-related quality of life in T2DM prefrail older adults. Therefore, it could be useful to include this kind of training in future similar situations.

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**TRAINING INDUCED CARDIO-RESPIRATORY FITNESS AND BODY COMPOSITION CHANGES IN ADULTS WITH TYPE 1 AND TYPE 2 DIABETES**

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**INTRODUCTION:**



It is well established that exercise is key in the management of diabetes and helps to reduce comorbidities (1). While most studies investigated the effect of supervised exercise programs (2), self-managed training seems more realistic to enhance long term involvement in physical activity. It is not clear if type 1 (T1D) and type 2 diabetes (T2D) respond similarly to exercise interventions.

**METHODS:**

Twenty-seven adults with T2D and 12 with T1D took part in a 12-week, 3 times weekly, self-managed exercise program performed in an easily accessible gym. Among them, 13 T2D (4 women; age  $52 \pm 8$  years old) and 5 T1D patients (3 women; age  $46 \pm 14$  years) completed at least 80% of the training sessions and were included in data analysis. Cardiopulmonary exercise testing (CPET) and body composition assessment with dual-energy x-ray absorptiometry were done before and after the intervention. The training program consisted of a combination of high intensity interval training (HIIT) on a stationary bike and strength training. HIIT was composed of 8 bouts of 2 minutes pedaling at 90% of maximal heart rate interspaced with 2 minutes of active rest. The strength part was composed of 4 exercises focusing the main muscle groups, with 3 sets of 10 repetitions for each exercise. After a first supervised training session, participants pursued the program on their own. All sessions were recorded using a physical activity tracker.

**RESULTS:**

After training, subjects improved their maximal aerobic power during CPET (T1D: +13%,  $p < 0.05$ ; T2D: +14%,  $p < 0.001$ ).  $VO_{2max}$  increased in T2D (+9%,  $p < 0.01$ ) and the  $CO_2$  respiratory equivalent at the anaerobic threshold decreased (-9%,  $p < 0.05$ ), reflecting smoothened chemosensitivity. Total fat mass decreased significantly in T2D patients (-3.6%,  $p < 0.01$ ), and a greater reduction was seen for visceral adipose tissue volume (-11%,  $p < 0.01$ ). Lean mass increased in participants with T2D (+2.1%,  $p < 0.05$ ). Similar (currently non-significant) trends for CPET and body composition were observed in T1D patients.

**CONCLUSION:**

This self-managed training program improves cardio-respiratory fitness and body composition in adults with T2D. Our preliminary results suggest that T1D patients have similar beneficial responses; additional participant recruitment is ongoing.

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**DOES FAMILY HISTORY OF TYPE 2 DIABETES IMPINGE UPON SUBSTRATE METABOLISM DURING SUBMAXIMAL EXERCISE?**

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**INTRODUCTION:**

Exercise is a cornerstone for the prevention of type 2 diabetes (T2D) in elderly people. Amongst the various mechanisms at play, a regular intramuscular lipids (IML) turnover was shown to improve insulin sensitivity through the reduction of multiples by-products. However, previous observations emerging from our research group have hinted towards a reduced ability to mobilize IML in postmenopausal women with a family history of T2D (FH+), compared with their counterparts without family history (FH-). The objective of this study was thus to verify with more robust methods if a family history of diabetes impinges on the ability to oxidize IML during aerobic exercise of light-to-moderate intensity.

**METHODS:**

Twenty inactive yet healthy women (FH-  $n=10$ , FH+  $n=10$ ) aged 60-75 years old underwent a 7-stage incremental exercise on cycle ergometer in which the intensity ranged from 40 to 70% of their maximal power output assessed a week earlier with a  $VO_2$  max test. Participants were subjected to a eucaloric standardized diet for 24 hours prior to testing and ingested 50 mg of  $^{13}C$ -Palmitate with a standardized breakfast 2 hours before the beginning of exercise. Gas exchange and heart rate were monitored continuously throughout the test. Breath and blood samples were taken at the end of each stage, in steady state conditions. Breath samples were analyzed with isotope-ratio mass spectrometry (IRMS) to determine the ratio of  $^{13}C:^{12}CO_2$  expired (upcoming results). Plasma concentrations of glucose, lactate, free-fatty acids, glycerol, ketone acids, catecholamines and  $^{13}C$ -Palmitate were measured (upcoming results).

**RESULTS:**

Preliminary results suggest no differences in maximal power output (FH-  $97.5 \pm 22.5$  W, FH+  $97.1 \pm 13.8$  W;  $p=0.595$ ), in absolute (FH-  $1.3 \pm 0.2$  L/min, FH+  $1.4 \pm 0.2$  L/min;  $p=0.247$ ) or relative  $VO_2$  peak (FH-  $19.4 \pm 4.0$  ml/min/kg, FH+  $20.0 \pm 3.0$  ml/min/kg;  $p=0.563$ ), and in the respiratory exchange ratio through the 7 stages (all  $p > 0.15$ ). However, the percentage of heart rate reserve attained during the latter stages of aerobic exercise (Stage 6: FH-  $89.5 \pm 8.1\%$ , FH+  $76.8 \pm 8.3\%$ ;  $p=0.028$  and stage 7: FH-  $95.1 \pm 6.2\%$ , FH+  $81.5 \pm 8.0\%$ ;  $p=0.006$ ) was significantly lower in FH+ compared to FH- despite similar absolute and relative workload, suggesting a possible disconnection between power output and oxygen uptake in FH+.

**CONCLUSION:**

To the best of our knowledge, this is the first study to investigate substrate metabolism during exercise in a population recognized to be at high risk of developing T2D. Upcoming IRMS and blood sample analyses will provide insightful data to better understand the impact of family history of T2D on substrate metabolism during aerobic exercise.

**BREAKS IN SITTING TIME ARE ASSOCIATED WITH HIGHER LIVER GLUCOSE UPTAKE IN METABOLIC SYNDROME PATIENTS**

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**INTRODUCTION:**

Metabolic syndrome is associated with insulin resistance, which can lead to type II diabetes (1). Decreased liver glucose uptake (GU) during insulin stimulation predisposes to postprandial hyperglycemia due to defective liver glycogen storage (2). However, the associations of body adiposity, sedentary behavior and physical activity on hepatic GU have not yet been fully established. Therefore, the aim of this study was to investigate the associations between hepatic GU, physical (in)activity, maximal oxygen consumption ( $VO_{2max}$ ) and fitness, body composition, and metabolic risk factors measured in blood in subjects at high risk for cardiometabolic diseases.

**METHODS:**

The participants comprised 25 women [mean age  $57.0$  (SD  $7.3$ ) years] and 19 men [mean age  $58.1$  (SD  $6.0$ ) years] with metabolic syndrome. Liver GU in liver was measured by positron emission tomography (PET) during hyperinsulinemic-euglycemic clamp. Body composi-

tion was measured by air displacement plethysmography (BodPod). VO<sub>2</sub>max was determined by a stepwise maximum bicycle ergometer test with respiratory gas measurements. Physical activity of the subjects was measured by hip-worn accelerometers for 26 (SD 2.6) days. Associations between variables were examined by sex adjusted correlation analysis.

**RESULTS:**

Liver GU in insulin stimulation correlated positively with whole body insulin sensitivity ( $r = 0.70$ ,  $p < 0.0001$ ) and negatively with fasting insulin ( $r = -0.34$ ,  $p = 0.03$ ), body fat percentage ( $r = -0.38$ ,  $p = 0.01$ ), and body mass index ( $r = -0.33$ ,  $p = 0.03$ ). Liver GU correlated positively with the number of daily breaks in sitting time ( $r = 0.37$ ,  $p = 0.02$ ). A positive trend was also seen between liver GU and the number of total daily steps ( $r = 0.28$ ,  $p = 0.07$ ), but no significant associations were detected between liver GU and daily total sitting or standing time, light or moderate-to-vigorous physical activity or VO<sub>2</sub>max or other fitness measures.

**CONCLUSION:**

In patients with metabolic syndrome patients more frequent breaks in sitting time were associated with lesser hepatic insulin resistance. Higher liver glucose uptake was also associated with more favorable body composition. Thus, liver health of patients with metabolic syndrome may benefit from interrupting prolonged sitting.

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**EFFECTS OF COMBINED LOW-VOLUME HIGH-INTENSITY INTERVAL AND STRENGTH TRAINING ON GUT MICROBIAL METABOLITES AND CARDIOMETABOLIC HEALTH IN OBESE INDIVIDUALS WITH METABOLIC SYNDROME: PRELIMINARY DATA**

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**INTRODUCTION:**

Both obesity and the metabolic syndrome (MetS) are associated with an increased risk of several comorbidities and mortality. The pathogenesis of obesity is multifactorial, involving factors linked to genetics, hormones and lifestyle. Recently, the gut microbiome and its role in the development of obesity and MetS have gained increased attention. Physical activity is a key component in the treatment of obesity and related disorders but the link with the microbiome is still in early stages of understanding. It has been shown, e.g., that athletes exhibit higher levels of fecal metabolites such as short-chain fatty acids (SCFA), which have been associated with positive effects on metabolic health [1]. However, recent research revealed that traditional moderate-intensity aerobic exercise had no impact on SCFA levels in obese subjects [2]. The aim of the present study was, therefore, to explore the effects of a more intense but less time-consuming exercise regime on gut microbial metabolites and cardiometabolic health in obese individuals with MetS.

**METHODS:**

Twenty-three obese individuals (53±12 yrs, BMI: 36.6±5.4) with clinical diagnosis of MetS performed a 12 week exercise program consisting of low-volume high-intensity interval training (HIIT, 5x1 min at 80-95% maximal heart rate on cycle ergometers) followed by a 1-set strength training (ST, 5 exercises, 8-12 reps at 70-80% of 1-rep max). Exercise was performed 2x weekly (total time per session: 35 min). Additionally, participants received nutritional counselling. Stool samples were collected to assess SCFA concentrations. Moreover, maximal oxygen uptake (VO<sub>2</sub>max), muscle strength of major muscle groups, selected cardiometabolic risk markers and the MetS-Z-Score were determined.

**RESULTS:**

The combined HIIT/ST program was well tolerated and no adverse events occurred. Body weight, body fat and waist circumference decreased significantly ( $p < 0.01$ ) by 3 kg, 1.1% and 4 cm on average. VO<sub>2</sub>max and muscle strength increased by ~9% ( $p < 0.01$ ) and ~24% ( $p < 0.001$ ). There was a significant increase in fecal total SCFA concentration (158±46 to 182±40 µmol/g,  $p < 0.01$ ), particularly due to an increase in acetate (91±24 to 103±22 µmol/g,  $p < 0.05$ ) and butyrate (32±13 to 40±16 µmol/g,  $p < 0.01$ ). Moreover, overall cardiometabolic health improved significantly (MetS-Z-Score: 1.2±2.9 to 0.3±2.7,  $p < 0.05$ ).

**CONCLUSION:**

The preliminary results of this study indicate that a combined low-volume HIIT /ST program that requires as little as 70 min/week may induce significant changes in gut microbial metabolites, physical fitness and cardiometabolic health in obese individuals with MetS. The discrepancy to previous research [2] could potentially be attributed to the higher exercise intensity and/or additional ST in the present study. Further research is needed to assess the role of exercise to alter microbiome and potential links to cardiometabolic health.

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**OP-MH02 Ageing, Exercise and Training**

**DOES AGE AND SEX MATTER AMONG THE RELATIONSHIP BETWEEN HISTORY OF PHYSICAL ACTIVITY LEVEL AND FUNCTIONAL CAPACITIES AND BODY COMPOSITION IN ELDERLY PEOPLE?**

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**INTRODUCTION:**

Being active and history of physical activity (PA) habits are nowadays recognized as important predictor to prevent physical aging. However, it is unclear if sex or age influence this relationship and if a sub-type of voluntary PA is more efficient to maintain healthy aging. Thus, we aim to assess the impact of the last 5-years of PA level and functional capacities and body composition among elderly people

**METHODS:**

Functional capacities using different validated tests (i.e. grip strength, Timed Up and Go, sit-to-stand, muscle power, alternate step test, leg extension, VO<sub>2</sub> max), body composition (fat & fat-free masses) using DXA were assessed. Last 5-years of global (total) and specific (aerobic,

resistance or body and mind) PA levels (duration) were obtained through a questionnaire. Multiple regressions, adjusted on age, sex and BMI, were performed to assess the relationship between past PA level and body composition or functional capacities. Sub-group analysis, according to the sex and age (<65y vs. ≥65y) were also performed using Pearson Correlations.

RESULTS:

525 subjects (61.7±8.1y; women: 68.9%; BMI=26.4±4.8kg/m<sup>2</sup>) were enrolled. After adjustment on confounding factors, past level of PA has no impact on functional capacities and body composition, regardless of sex. Among people under 65 years, there is no relationship between time spent on total physical activity and functional capacities or body composition. However, our study found a significant correlation between total physical activity and balance (r=0.19; P=0.01), alternate-step test (r=0.24; P=0.02) and VO<sub>2</sub> max (r=0.19; P=0.02) in people aged 65 and over. More precisely, the time spent on cardio and resistance activities influence balance (r=0.16; P=0.03 and r=0.15; P=0.04, respectively) in this age category.

CONCLUSION:

Our results highlights that PA history has little or no influence on functional capacities and body composition in healthy aging population.

**PREDICTION EQUATIONS FOR CARDIORESPIRATORY FITNESS IN OLDER ADULTS.**

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INTRODUCTION:

Cardiorespiratory fitness (CRF) is an important marker of health and is inversely associated with all-cause mortality. However, to obtain an accurate and precise measurement of CRF is necessary to perform an incremental cardiopulmonary exercise test (CPET) until exhaustion. This CPET entails certain health and physical risks, especially for older adults, as well as require high precision and expensive equipment that hamper its implementation in large scale studies and clinical settings. Therefore, the main aim of this study is to suggest alternative equations to predict CRF in older adults between 65 and 75 years.

METHODS:

92 older adults (68.9±2.9 years, 41 women) were finally recruited. Participants completed evaluation separated dimensions: (i) A questionnaires session on sociodemographic characteristic and self-reported physical activity pattern, (ii) body composition using anthropometric and bioimpedance analysis (TANITA-MC780MA), (iii) physical fitness levels (handgrip, chair stand and 6 minutes walking tests (6MWT)), (iv) pulmonary function by a spirometry test (v) resting metabolic rate (RMR) and VO<sub>2</sub>peak through indirect calorimetry and incremental CPET. "Allset" regression non-native command from STATA software was applied to found the best of 65,535 possible regression models executed for each condition.

RESULTS:

68 participants achieved maximal criteria during CPET, meeting at least three of the following criteria: (i) RER≥ 1.05, (ii) a plateau of VO<sub>2</sub> achieved in last three intervals of 10 seconds (<2 mL·kg<sup>-1</sup>·min<sup>-1</sup>), (iii) subjective volitional exhaustion, (iv) heart rate reserve (HRR) ≥ 85% and (v) subjective exertion ≥ 7. We selected the five best prediction models using basic variables (all p<0.001, all R<sup>2</sup>=0.75 and Mallow's Cp range from 0.01 to 1.73), with the first model using only three variables (RMR, 6MWT and HR basal; p<0.001, r<sup>2</sup>=0.75 and Mallow's CP=0.01). The five best models using basic variables and spirometry test showed higher prediction of CRF (all p<0.001, R<sup>2</sup> range from 0.76 to 0.77 and Mallow's Cp from 3.31 to 4.81), founding a first model with four variables [RMR, 6MWT, basal HR and forced expiratory volume in 1 second (FEV<sub>1</sub>); p<0.001, r<sup>2</sup>=0.77 and Mallow's CP=3.31]. Finally, the five best models using basic variables, spirometry and variables of CPET showed the best prediction of CRF (all p<0.001, R<sup>2</sup> range from 0.86 to 0.87 and Mallow's Cp from 2.50 to 4.10). The best prediction model was composed by four variables (RMR, FEV<sub>1</sub>, peak HR during CPET and time to exhaustion; p<0.001, R<sup>2</sup>=0.77 and Mallow's CP=3.31).

CONCLUSION:

This study provides fifteen equations with high prediction values of the CRF for older people between 65 and 75 years that could be used based on the availability of resources and equipment but with a good prediction rate. The non-exercise models proposed explain 77% of the variability of the CRF and using data from the CPET without complex sensors we have achieving to explain 87% of the variability of the CRF.

**WHICH BALANCE AND MOBILITY TESTS ARE ASSOCIATED WITH A HISTORY OF FALLS IN THE COMMUNITY-DWELLING ELDERLY?**

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INTRODUCTION:

Falls are the main cause of mortality and morbidity in the older population. More than 30% of people over 60 years old experience at least one fall each year and usually suffer from consequent injuries, and subsequent fear of falling, reduced independence and even early death. Balance and mobility tests, such as the 30 seconds sit-to-stand test (30STS), timed up and go test (TUG) and 6 minutes walking test (6MWT), are commonly used with this population. The current retrospective study aimed to explore the association between these balance and mobility performance scores and history of falls in Chinese community-dwelling elderly.

METHODS:

In this retrospective study, a total of 74 elderly (age 72.55±7.47 years old, range: 60-91 years old; height 162.80±7.05cm, range: 148.00-176.00cm; weight 62.11±9.11kg, range: 45.00-91.90kg) were recruited from 9 communities in Shanghai. Seven participants were fallers and 67 were non-fallers. Balance and mobility were measured using the 30STS, TUG and 6MWT. The independent-samples t-test was employed to evaluate the differences between fallers and non-fallers. Spearman's correlation was conducted to investigate the relationship between falls, age, height, weight, 30STS, TUG and 6MWT. The receiver operating characteristic (ROC) curve was constructed and the area under the ROC curve (AUC) interpreted as a measure of classification ability of the test and the curve was used to determine the cut-off point for prediction faller status.

RESULTS:

The average scores for fallers and non-fallers for 30STS, TUG and 6MWT were: 12.14±3.39reps vs 16.70±4.36reps, 8.53±0.77s vs 9.09±2.17s, 445.14±80.48m vs 426.64±89.26m, respectively. Fallers performed significantly worse in the 30STS (p=0.009). Spearman's

correlation analysis indicated that fall status was significantly associated with 30STS ( $r=-0.297$ ,  $p=0.01$ ) and weight ( $r=0.255$ ,  $p=0.028$ ). Moreover, the AUC of 0.80 ( $p=0.011$ ,  $95\%CI=0.654$ ,  $0.930$ ) showed that 30STS performance was a significant predictor of history of falls status, with a cut-off point at 16.5 repetitions (Sensitivity=1, Specificity=0.507).

#### CONCLUSION:

Results from the current retrospective study suggest that the 30STS is valid for predicting falls status in community-dwelling elderly. The cut-off point of 16.5 repetitions should be considered when evaluating the risk of falls and designing physiotherapy programs. A future large sample prospective study is warranted to examine balance and mobility tests for their ability in predicting falls in community-dwelling older people.

### MOBEMENT STUDY: WRIST AND HIP ACCELEROMETER CUT-POINTS VALIDATION IN OLDER ADULTS OVER 65 YEARS OLD.

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#### INTRODUCTION:

Accelerometer devices have become the principal research method for sedentary behaviour and physical activity objective quantification. However, they are not exempt of bias. In this regard, the choice of appropriate cut-points considering the characteristics of the population studied is decisive for an accurate estimation. Scientific evidence points to a lower rest energy expenditure in older adults comparing to young adults (1). Therefore, a sedentary time and physical activity misclassification could occur if a Metabolic Equivalent of Task (MET) of 3.5 ml/kg-1/min-1 is assumed in older adults. Thus, the aim of this study was to validate specific accelerometer cut-points for older adults over 65 years old based on relative rest metabolic rate.

#### METHODS:

Fifteen older adults ( $\geq 65$  years old) were included in these analyses. Rest metabolic rate (RMR) was evaluated and activities of daily living were performed in a laboratory setting pretending to represent sedentary behaviour (SB) intensity ( $\leq 1.5$  METs), light physical activity intensity ( $>1.5$  to  $\leq 3$  METs) and moderate-to-vigorous physical activity (MVPA) intensity ( $>3$  METs). During this protocol, each subject wore a GENEActiv (ActivInsights Ltd., Cambridge, UK) accelerometer attached to both right hip (RH) and non-dominant wrist (NDW), and equipped with a Cosmed k-5 (COSMED, Rome, Italy) indirect calorimeter. Finally, raw accelerometer data was processed and converted to ENMO units (2) and averaged every 10s together with metabolic outcomes. METs values were estimated based on relative RMR obtained from each subject. Receiver Operating Characteristic (ROC) curve analyses were used to determine SB and MVPA cut-points. Area under the curve (AUC) was calculated and cut-points were selected using the Youden Index.

#### RESULTS:

An average MET value of  $2.98 \pm 0.72$  ml/kg-1/min-1 (Mean  $\pm$  SD) was obtained. Considering RH placement, ROC curve analysis revealed an AUC of 0.92 (95% CI: 0.90–0.93;  $P<0.001$ ) for SB and 0.93 (95% CI: 0.92–0.94;  $P<0.001$ ) for MVPA. In the case of NDW, ROC curve analysis showed an AUC of 0.87 (95% CI: 0.86–0.89;  $P<0.001$ ) for SB and 0.94 (95% CI: 0.94–0.95;  $P<0.001$ ) for MVPA. RH cut-points were SB: 13 mg (Se=91%, Sp=82%) and MVPA: 23 mg (Se=91%, Sp=83%), and NDW cut-points were SB: 41 mg (Se=98%, Sp=78%) and MVPA: 49 mg (Se=97%, Sp=81%).

#### CONCLUSION:

Derived cut-points showed generally excellent quality values. Thus, pending a suitable cross validation, they seem to be a reliable option for their application during the sedentary behaviour and physical activity quantification process, in older adults over 65 years old.

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### PHYSIOLOGICAL AND EXERTIONAL RESPONSES OF BALLROOM DANCING IN ELDERLY

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#### INTRODUCTION:

In order to verify if ballroom dancing is an appropriate physical activity (PA) for elderly it is necessary to analyse the ballroom dancing itself. Until now, the existing research studied traditional and folk dance<sup>1,2</sup>, or partner dancing<sup>3</sup> only in adults. Therefore, the aim of this study was to examine physiological and exertional responses during smooth and unified ballroom dance in elderly.

#### METHODS:

Twenty healthy amateur ballroom dancers (10 men and 10 women, age  $72.0 \pm 5.9$  yrs, BMI  $25.5 \pm 4.2$  kg/m<sup>2</sup>) with multiyear ballroom experience performed 3 different kinds of ball (choosing between Mazurka, Viennese Waltz and Polka or Slow Waltz, Tango and Foxtrot), each lasting 3 minutes, with a 3-minute recovery between consecutive balls. Cardio-respiratory data were continuously recorded with a portable metabolimeter (K5, Cosmed, Italy) in order to assess Metabolic Equivalent Task (METs) ( $V'O_2$ mean mlO<sub>2</sub>/kg/min / 3.5). The Borg Category-Ratio anchored at the number 10 (CR10 scale) was used to assess perceived effort (RPE) at the end of each ball.

#### RESULTS:

There were no gender differences in METs and RPE. Similarly, no differences in RPE were observed between balls. The mean METs for smooth ballroom dance were: Tango  $4.3 \pm 1.1$ , Slow Waltz  $4.4 \pm 1.4$  and Foxtrot  $4.8 \pm 1.4$  METs, respectively; the mean METs for unified ballroom dance were: Mazurka  $5.2 \pm 1$ , Viennese Waltz  $5.8 \pm 0.9$  and Polka  $5.9 \pm 1$  METs, respectively). Polka elicited significantly higher METs values than Tango ( $p<0.003$ ) and Slow Waltz ( $p<0.002$ ).

#### CONCLUSION:

Physiological and exertional responses were unaffected by gender, consistent with the findings of Usagawa<sup>2</sup> and Guidetti<sup>3</sup>. Our data complement the results of other studies that have classified different kinds of dance through energy expenditure<sup>1,2</sup>, analysing a wide-spread leisure activity among elderly, and using METs. In general, unified and smooth ballroom dance demanded moderate to vigorous PA intensity levels. In fact, according to the classification of exercise intensity for 65 years old<sup>4</sup>, Tango and Slow Waltz were performed in moderate intensity (3.2–4.7 METs), whereas the others in vigorous intensity (4.8–6.7 METs). Therefore, all studied dance styles may serve as a legitimate form of PA for elderly, meeting the suggested intensity of the current guidelines for elderly<sup>5</sup>.

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### **INDIVIDUAL TRAINING MONITORING AND RESPONSE DURING STABLE VS. UNSTABLE BALANCE EXERGAMING IN HEALTHY ELDERLY ADULTS: A SECONDARY ANALYSIS OF A RANDOMIZED CONTROLLED TRIAL**

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#### **INTRODUCTION:**

Individual load monitoring and assessment are crucial for evaluation of subsequent adaptational processes. The effects of different internal responses to external stimuli throughout an entire interventional cycle are often neglected or inadequately addressed. This secondary analysis of a 3-armed RCT on volitional step training under stable and unstable conditions in seniors on neuromuscular performance intended to elucidate whether perceived effort, progression and instability level moderate the occurrence and magnitude of intervention effects.

#### **METHODS:**

A total of 51 healthy seniors (age:  $69 \pm 6$  years) were allocated to either volitional stepping (VOL), volitional stepping under unstable conditions (VOL + US) or an inactive control group (CON). Before and after the intervention balance- & strength performance and functional capacity were assessed. VOL and VOL + US completed eight weeks of exergame based step training (three weekly sessions, 45 min each) using a Dividat Senso device with twelve different balance games. The original rigid platform was employed for VOL, whereas VOL + US trained on an adapted Senso mounted on a swinging Posturomed System. Instability level (external load) was only increased for VOL + US every second week. External (degree of stability) and internal (game scores, perceived efforts, using the rated perceived exertion scale (RPE)) load measures were individually captured during all sessions. Statistical analyses were carried out using linear mixed-effects modeling.

#### **RESULTS:**

Although VOL + US completed the same games at identical training volumes under unstable conditions, the achieved game scores did not significantly differ between the groups ( $p = 0.71$ ). Both intervention groups significantly improved their z-transformed game scores over the eight weeks ( $p < 0.01$ ). Interestingly, a time x group interaction effect was highly significant ( $p < 0.01$ ) for the internal load measured with the RPE scale. Subsequent, post-hoc testing revealed significant higher perceived exertion values in each of the first seven weeks ( $p < 0.05$ ) in VOL + US compared to VOL. As the exertion values in VOL + US decreased over time (week 1:  $4.6 \pm 1.9$ ; week 8:  $3.1 \pm 1.6$ ), VOL indicated similar RPE values over time (week 1:  $3.1 \pm 1.3$ ; week 8:  $2.9 \pm 1.4$ ) and no differences in week 8 was observed ( $p = 0.74$ ). A detailed analysis of all twelve games revealed that the perceived exertion differed depending on the game content: in 75% of the involved games the RPE level was significantly higher in VOL + US compared to VOL ( $p < 0.05$ ).

#### **CONCLUSION:**

The integration of external and internal load monitoring are paramount for successful individual exercise training programming. The results further demonstrate how virtual reality training (VRT) enables individual and progressively challenging neuromuscular exercise training. For this purpose, perceived efforts should be gradually adapted in order to provide adequate training stimuli on individual level.

### **EFFECTS OF A MULTIMODAL AGILITY-BASED EXERCISE TRAINING INTERVENTION OVER 24 WEEKS ON NEUROMUSCULAR FALL RISK PARAMETERS IN HEALTHY SENIORS: A 2-ARMED RCT**

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#### **INTRODUCTION:**

Demographic change mainly in Western societies leads to higher prevalence of diseases and elevated fall rates in elderly people. The process of biological aging leads to morphological and functional deterioration of several functional systems. Exercise training has been shown to mitigate these aging induces declines and can beneficially affect risk factors for frailty, falling and cardiovascular diseases. As multimodal exercise training is particularly considered beneficial, a newly developed multimodal agility framework that combines strength, coordination, stop and go, cutting, spatial orientation and balance exercises with cognitive and reactive tasks has been applied and examined (1). The aim of this RCT is to investigate whether 24-week of agility training for seniors on the neuromuscular parameters of fall prevention.

#### **METHODS:**

Participants were minimized (strata: age, sex, BMI, physical activity) to either an intervention (ATG) or control group (CG). ATG ( $n=33$ ,  $69.2 \pm 4.6$  yrs,  $77.5 \pm 14.8$  kg,  $1.7 \pm 0.1$  m) received two weekly 60-minutes training sessions, while CG ( $n=40$ ,  $69.2 \pm 4.5$  yrs,  $76.4 \pm 14.4$  kg,  $1.7 \pm 0.1$  m) only received an informative written advice including general health related physical activity recommendations. ATG consisted of start-and-stop movements, change of directions, dynamic balance exercises that were progressively complemented by cognitive and/or reactive task. The complexity of the agility components increased with time. Primary and secondary were handgrip strength, maximum isometric force of the thigh muscles ( $F_{max}$ ,  $F_{rel}$ ,  $RFD$ ), the gait speed (single, dual-task and triple-task conditions), the jumping height (CMJ) and the static and dynamic balance ability. All outcomes were tested before and after the intervention period.

#### **RESULTS:**

A significant and moderate group x time interaction effect was observed for the CMJ ( $F [1,62] = 7.51$ ,  $p=0.008$ ,  $\eta^2p = 0.11$ ). Subsequent post-hoc testing revealed that the CG has slightly lower results in jump in the post-test ( $0.128 \pm 0.040$  m) compared to the pre-test ( $0.136 \pm 0.041$  m), whereas ATG remained unchanged (pre:  $0.146 \pm 0.052$  m, post:  $0.150 \pm 0.046$  m). All other outcomes did not reveal but no any relevant or significant group x time interactions (0.064).

#### **CONCLUSION:**

Multimodal agility-based exercise training over 24 weeks does not seem to directly affect muscle strength in the lower extremities and balance abilities. It appears that seasonal declines of explosive power (i.e. CMJ) could be attenuated via agility training. Thus, even longer interventional time frames do not increase the transferability of interventional effects to other non-trained lab tests. Overall, future studies should investigate the effects of studies over one year and testing should be functionally aligned with trained tasks that are highly relevant for daily functional or sportive live of the respective population.

#### **References**

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## EFFECTS OF ISO-POTENTIAL STRENGTH TRAINING PROGRAMS DIFFERENTIATED ACCORDING TO THE SPEED OF EXECUTION AND LOAD INTENSITY ON THE MAXIMAL STRENGTH RELATED TO THE HEALTH OF ELDERLY PEOPLE.

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### INTRODUCTION:

It has been observed that the loss of muscular performance with aging, in particular the ability to generate strength and power, occurs earlier and at a higher rate than the loss of muscle mass (1). Given that the power is the result of the product of force and velocity, the influence of the velocity and force at which the maximum power is reached on functionality has been recently analysed (2).

The inverse force-velocity relationship (FV) implicitly implies a parabolic relationship between power and velocity and therefore the existence of a peak value of power with an optimal velocity, which in turn it's equivalent to a value of force in the FV. This parabolic profile of the power-velocity relationship means that there are iso-power points, that is, power levels that can be performed at different velocities (2).

Considering the relevance of the preservation of power for the maintenance of functionality, and in turn the importance of optimal velocity, we hypothesized that iso-potential training, performed at different load at different velocity, would be associated with different values of the variables representative of the physical condition related to health.

### METHODS:

Thirty-seven active adults, older than sixty years were randomized (high velocity, HV; low velocity, LV; and control, CON) to obtain the one repetition maximum (Egym, Germany) the load-power ratio (% 1RM-W) through a progressive load test (lat pull, LP; chest press, CP; leg press, LgP), before and after a power training intervention (5 weeks; 2 sessions per week). The power training was developed in two training isopower models, where load intensity and speed of execution were differentiated when performing at maximum intended velocity. The total volume and recovery were equated between experimental groups.

### RESULTS:

1RM increased after training in both HV ( $p < 0,001$ ; Hedge's  $g: 0,324$ ) and LV ( $p < 0,001$ ; Hedge's  $g: 0,423$ ). Similar results were observed for LgP ( $p < 0,001$ ; Hedge's  $g: 0,505$ ;  $p < 0,001$ ; Hedge's  $g: 0,404$  for HV and LV respectively). For CP the 1RM increase in all the groups, although the effect size was lower in C ( $p < 0,039$ ; Hedge's  $g: 0,089$ ) than in both HV ( $p < 0,001$ ; Hedge's  $g: 0,385$ ) and LV ( $p < 0,001$ ; Hedge's  $g: 0,731$ ).

### CONCLUSION:

Power training with older adults is a good method for increase the maximal strength. For a similar power performance, the effects were similar for high load-low velocity and low load-high velocity protocols.

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## A CONTINUOUS FALL RISK SCORE IN COMMUNITY-DWELLING OLDER ADULTS

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### INTRODUCTION:

Older adult's fall risk identification is of major importance to provide adequate prevention measures. Current predictive models do not adjust to contextual experiences, considering risk factors for falls to be stable for each person and not to change over time [1]. Continuous risk scores did already prove its validity and utility to clinical practice in other diseases, such as for the metabolic syndrome diagnosis [2]. In this study, we aim to reduce a set of correlated fall risk outcomes to a continuous fall risk score (cFRs) for community-dwelling older adults through standardized residuals and then examine its construct validity.

### METHODS:

Self-reported falls in the last year were recorded from 452 older adults ( $73.6 \pm 6.2$  years old). Participants were categorized as non-fallers (falls = 0), occasional-fallers (falls = 1), recurrent-fallers ( $>1$  falls  $\leq 4$ ) and chronic-fallers ( $\geq 5$  falls). A cFRs was created for each participant based on the following intrinsic fall risk factors and exposures: body strength, agility, balance, aerobic endurance, physical activity, cognitive deficits, environmental hazards, health conditions, sleepiness, physical independence, and body composition. The cFRs was derived by first standardizing the individual cFRs variables. Standardized variables inversely related to falls occurrence, according to literature, were multiplied by -1. Finally, standardized residuals (Z-scores) for cFRs variables were summed to create the cFRs.

### RESULTS:

There was a graded relationship between the cFRs and the reported falls. The cFRs was lowest in non-fallers ( $-1.17 \pm 5.80$ ), higher in occasional-fallers ( $0.72 \pm 6.39$ ), even higher in recurrent-fallers ( $2.16 \pm 7.35$ ), and highest in chronic-fallers ( $4.60 \pm 5.28$ ). The cutoff level yielding the maximal sensitivity and specificity for predicting regular falls occurrence (falls  $\geq 2$ ) was a cFRs of 4.09 (sensitivity = 42%, specificity = 81%), and the area of the curve = 0.639 (0.573 - 0.705, 95% confidence intervals).

### CONCLUSION:

The cFRs showed to be a valid alternative for epidemiological analyses and clinical practice, proving its potential to become a widely used approach regarding fall prevention in community-dwelling older adults. Further investigation is required to validate the cFRs with other samples since it is a sample-specific method.

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**ARE SHORT-TERM PHYSICAL EXERCISE INTERVENTIONS IN LONG-TERM NURSING HOMES EFFECTIVE IN THE LONG-TERM?**

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**INTRODUCTION:**

Recently, we carried out a randomized controlled trial (RCT) with the aim of assessing the effectiveness of a multicomponent individualized and progressive physical exercise program at moderate intensity in older people living in long-term nursing homes (LTNH)<sup>1,2</sup>. This program significantly improved physical and cognitive performance in participants. Aiming to ascertain whether these benefits were maintained after finishing the program, we carried out a six-month follow-up.

**METHODS:**

112 older adults living in LTNHs participated in a RCT (ACTRN12616001044415). Inclusion criteria were:  $\geq 70$  years,  $\geq 50$  Barthel index,  $\geq 20$  MEC-35 and being able to stand up from a chair and walk 10 meters independently. In this research, we analyzed the effects of a 6 month intervention and 6 month follow-up period after the intervention in a subsample of 31 participants. Subjects ( $n=16$ ), allocated to the intervention group (IG), participated in a multicomponent individualized and progressive physical exercise program at moderate intensity. Subjects (CG) of the control group (CG) continued with their usual activities during this period. Physical performance was evaluated with the Short Physical Performance Battery (SPPB) test and cognitive status with the Montreal Cognitive Assessment (MoCA) test. We also monitored the physical activity of the residents by accelerometry. The study was approved by the Committee on Ethics in Research of the University of the Basque Country (M10/2018/171).

**RESULTS:**

After the program, there was more than a 2-point improvement in the SPPB (paired t-test,  $p<0.001$ ) and a 2.5-point improvement in the MoCA test (paired t-test,  $p<0.05$ ) in the IG, while the CG showed a non-significant decline in both tests. However, the number of steps per day taken by the participants of the IG did not change significantly after the program. During follow-up, the values of SPPB and MOCA decreased by 2 points, returning practically to the figures measured at baseline. These differences were significant for SPPB ( $p<0.05$ ).

**CONCLUSION:**

These results indicate first, that this kind of short-term program, although effective for improving physical fitness and cognitive status, is not able to increase the amount of physical activity of older people living in LTNHs. Secondly, after finishing the program, the benefits are not further maintained and the sedentary behavior of the participants might reverse the benefits in physical and cognitive performance resulted from the intervention. After considering these results, we feel that physical exercise at moderate intensity should be an essential component of the routine activities of LTNHs and should be maintained throughout the lives of NH residents without interruption.

**OP-MH03 Injury risk factors****PROTEINURIA AND BILIRUBINURIA AS INDICATORS OF ACUTE KIDNEY INJURY IN ENDURANCE MOUNTAIN RUNNERS**

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**INTRODUCTION:**

Transitional Acute Kidney Injury (AKI) has been reported as a relatively uncommon but serious condition with an increasing incidence in endurance running (1). Factors as dehydration, metabolic load, and heat strain may influence in AKI incidence. Muscle damage and subsequent inflammatory responses could be a consequence of consecutive eccentric-concentric muscle contraction during mountain running and a potential cause of AKI (2). This study aimed to explore which urinary variables may indicate AKI in mountain runners.

**METHODS:**

Twenty-nine mountain runners (age  $39.1 \pm 8.8$  years, weight  $71.9 \pm 11$  kg, height  $171.9 \pm 8.3$  cm) completed a 35km event (cumulative positive ascend of 1815m, altitude= 906-1178 masl, temperature= $25.52 \pm 1.98$  °C, humidity= $79.25 \pm 7.45\%$ ). Two groups (AKI=17 and No-AKI=12) were made considering acute kidney injury criteria based on pre and post-race values of serum creatinine (sCr) (an increase of 1.5 times from baseline) (3). Serum blood tests were performed using a photometric and automatic analyzer (BS-200E, Mindray, China). Urinalysis was performed using dipsticks (Combur10Test M, Roche, Mannheim, Germany). Two participants groups were made based on the urinalysis findings (variables score  $>1$  or  $<1$ ). Both blood and urinalysis were performed immediately pre and post-race.

**RESULTS:**

There were 17 participants that met AKI criteria (sCr=  $1.18 \pm 0.26$  pre,  $1.8 \pm 0.35$  post). The 52.94% of these runners presented a significant increase of proteinuria ( $\chi^2=0.94$ ,  $p=0.01$ ) and 47.06% bilirubinuria ( $\chi^2=0.94$ ,  $p=0.04$ ) when compared pre vs post-race values. No significant increases were found in leucocyturia (17.64%,  $\chi^2=0.96$ ,  $p=0.5$ ), urobilinogenuria (17.64%,  $\chi^2=0.23$ ,  $p=0.63$ ), hematuria (29.41%,  $\chi^2=0.58$ ,  $p=0.13$ ). No nitrituria, glucosuria or ketonuria were found.

Besides, 12 participants did not develop AKI (sCr=  $1.28 \pm 0.28$  pre,  $1.5 \pm 0.3$  post). Proteinuria (33.33%,  $\chi^2=1.67$ ,  $p=0.25$ ), ketonuria (16.66%,  $\chi^2=0.28$ ,  $p=1$ ), bilirubinuria (41.66%,  $\chi^2=0.74$ ,  $p=0.63$ ), urobilinogenuria (8.33%,  $\chi^2=0.12$ ,  $p=1$ ) and hematuria (33.33%,  $\chi^2=2.59$ ,  $p=0.5$ ) were found but with no significant change. No cases of leucocyturia, nitrituria or glucosuria were presented in No-AKI group.

**CONCLUSION:**

The release of protein and bilirubin in urine may evidence a decrease in renal function due to muscle damage and inflammatory response. The presence of AKI cases with concomitant proteinuria and bilirubinuria may suggest the potential use of urinalysis as an accessible alternative to early identify AKI cases in the field.

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**TOO LITTLE TOO LATE?: RUNNERS SEEKING FOOTWEAR AND GAIT ADVICE ARE ALREADY INJURED.**

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**INTRODUCTION:**

Participation in recreational and distance running has increased in recent years, in part due to the low cost and accessibility, but despite evidence of benefits to health and well-being, injury prevalence is high and running-related injuries constitute a major health concern. The multifactorial nature of such injuries makes prevention challenging, with factors such as running distance, footwear, muscle weakness, faulty mechanics and poor training strategy linked to increased risk. This study aimed to investigate injury patterns and risk factors in runners attending a footwear prescription clinic for gait and foot assessment.

**METHODS:**

A retrospective cohort study was designed to investigate the prevalence of running related injuries and determine trends in the population. Anonymised self-reported data relating to 1000 runners (614 males and 386 females) who attended a sports clinic for gait analysis and footwear prescription were sampled and analysed to determine injury prevalence and patterns. Pearson chi-square tests for independence were used to analyse categorical variables to compare groups based on running distance and gender.

**RESULTS:**

Injury prevalence in the analysed population was 81.5% and a greater proportion of runners reported multiple (2 or more) injuries (26.0%) than no injuries (18.5%). No significant difference in injury risk was found between short- (n=660), middle- (n=256) or long- (n=84) distance runners (short = 81.2%, middle = 80.5%, long = 86.9%;  $p > 0.05$ ). Females reported significantly greater injury prevalence than males overall ( $p < 0.05$ ) and within each distance group, with the greatest difference observed in middle distance runners (females 91.5%, males 76.0%). Knee injuries were the most common injuries reported, followed by those of the foot and shank and a significantly higher number of hip injuries were reported by females than males (females = 11.8%, males = 4.6%;  $p < 0.05$ ).

**CONCLUSION:**

Overall, prevalence of injury was very high in the analysed population, suggesting that most of those seeking advice on gait and footwear are already injured. With previous injury being one of the most commonly identified risk factors in research to date and both appropriate footwear and gait training identified as potentially effective strategies for injury reduction, further research should focus on development of strategies to protect from running related injury through gait education, exercise intervention and footwear recommendation.

**EPIDEMIOLOGY OF ANKLE INJURIES IN U.S. RUGBY 7'S: A SEVEN YEAR ANALYSIS**

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1: UM-MOI, 2: RRIPG-HSS, 3: AUT/SPRINZ, 4: NYU, 5: HSS, 6: NBA, 7: USA BASKETBALL, 8: USAR EMPIRE/NEW ENGLAND, 9: NRODA

**INTRODUCTION:**

Rugby-7s is a growing popular format of Rugby being played among amateur populations within the U.S. Given its relative open and fast-paced format, lower extremity injuries including ankle injuries occur with relative frequency (Ma et al, 2016). The aim of this study was to determine the incidence and nature of match ankle injuries in amateur U.S. Rugby-7s.

**METHODS:**

A prospective epidemiology study of player injury encounters at USA Rugby Club 7-a-side competitive tournaments from 2010-2016. Match injury data and mechanisms were captured via the Rugby Injury Survey & Evaluation (RISE) Report (Lopez et al, 2012), following the rugby consensus statement (Fuller et al., 2007). Incidence (per 1000 ph), proportion (%), and severity of injuries (days) were determined.

**RESULTS:**

Overall match ankle injuries were found at 9.9/1000ph (n=313) (time-loss 2.5/1000ph, n=78; medical attention 7.4/1000ph, n=235). Females (3.5/1000ph; 12.3%) encountered fewer overall ankle injuries than males (7.6/1000ph; 10.8%; n=239). Backs (59%) were responsible for a greater proportion of ankle injuries than forwards (35%). Overall mean ankle injury severity was 41.5 days (CI: 24.4-58.6) with 68% follow-up. Greatest severity for ankle injuries were among College level competitors (105.6 days). Majority of ankle injuries occurred during the tackle (61%, 5.2/1000ph) and open play (29%, 2.5/1000ph). Regarding mechanisms of time-loss ankle injuries, direct-contact mechanisms resulted in 68% (1.7/1000ph) of time-loss ankle injuries versus non-contact (32%; 0.8/1000ph). Severity of contact versus non-contact ankle injuries did not differ (contact: 43.1 d; noncontact: 38.0 d). Most time-loss ankle injuries within the study period were new injuries (71.8%) compared to recurrent time-loss ankle injuries (28.2%). Recurrent ankle injuries occurred more frequently at greater-than-12-months (12.8%) followed by 2-month (10.3%).

**CONCLUSION:**

Amateur U.S. Rugby-7s population ankle injury rates (2.5/1000ph) were lower than the incidence reported for International elite Rugby-7s play (time-loss: 7.1-25/1000ph). The proportion of recurrent ankle injuries, particularly the early recurrence injuries, highlights the importance of post-tournament medical care and proper return-to-sport protocols to minimize re-injury. Appropriate proprioception and agility training awareness is also suggested, particularly given the high proportion of recurrent ankle injuries that occurred in a delayed fashion.

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**CONSEQUENCES AND PREDICTION OF HAMSTRING MUSCLE INJURY WITH CONCENTRIC AND ECCENTRIC ISOKINETIC PARAMETERS AND NEUROMUSCULAR ANALYSIS IN ELITE SOCCER PLAYERS**

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**INTRODUCTION:**



Hamstring muscle strain injuries (HMSI) are most prevalent injuries in sports and most hazardous in disciplines that involve high-speed running, such as sprinting or soccer (1). Epidemiological studies manifest an incidence of 30% (2) with recurrence rates of 45% (3). Injury events are characterized by eccentric (ECC) loading, where the entire, active muscle tendon unit experiences a passive lengthening producing microscopic damage of muscle fibres (1). Despite full voluntary effort, neuromuscular activation can be inhibited during ECC contractions (4). We aimed to compare neuromuscular correlates and biomechanics during maximal concentric (CON) and ECC knee flexions, hypothesizing that inhibition of neuromuscular activation may result from a history of HMSI.

**METHODS:**

41 elite male soccer players with previous history of unilateral HMSI and 40 uninjured athletes participated in this study. Isokinetic knee joint torques and electromyographic signals (EMG) of the M. biceps (BF) and quadriceps femoris (RF) were obtained during unilateral maximal CON and ECC knee flexions performed at two angular speeds (30 and 120°/s) within a range of 0° to 110° (4). Peak torque, joint position at peak torque, hamstring:quadriceps torque ratios, EMG integrals and the co-contraction index were assessed. Mean power frequency was calculated as the frequency centroid of the EMG spectrum. We evaluated statistical differences using a two-factor ANOVA and linear regression models.

**RESULTS:**

In previously injured muscles, ECC torque peaked at significantly shorter lengths (52°) than for uninjured muscles (31°) at both movement speeds. ECC flexion peak torque (-10Nm,  $p < .05$ ) and hamstring:quadriceps torque ratio (-13%,  $p < .05$ ) were reduced in the previously injured vs. uninjured muscles. Likewise, integrated BF EMGs (-5%) and mean power frequency (-18Hz,  $p < .05$ ) were reduced; the co-contraction index increased (+14%,  $p < .05$ ). Regressions revealed a positive association for side-to-side differences in ECC flexion peak torque and co-contraction index ( $p < .05$ ,  $F = 20.85$ ). The change in joint position at peak torque was negatively related to the integrated BF EMG ( $p < .05$ ,  $F = 17.03$ ).

**CONCLUSION:**

The current study provides novel knowledge about the fundamental influence of the complex neuronal control of the skeletal muscle during ECC movements and its association with strength deficits after HMSI injuries. The reduced peak torque at greater knee flexion of previously injured muscles concomitant with the a diminished neuronal drive reflected by a reduced EMG activation and frequency (4) makes the affected muscle-tendon complex more prone to damage from ECC loading than uninjured muscles and this may account for the high reinjure rate (2). To reduce the incidence of strain injuries, it is recommended that a combined program of ECC exercise and muscle testing should be carried out (1).

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4 Aagaard, P. JSHS, 2018

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**INJURY IN ELITE GOLFERS: POOR SPINAL MUSCLE RECRUITMENT STRATEGIES DURING THE SWING, IS LINKED TO DEVELOPING BACK PAIN IN ELITE GOLFERS.**

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**INTRODUCTION:**

This study presents an electromyography (EMG) measure of muscle activity prior to the development of back injury in elite golfers and aims to provide constructive insight into the mechanism of back injury in elite golfers. Elite golfers frequently injure their lumbar spine (Cabri, Sousa, Kots, & Barreiros, 2009). Changes in muscle function have been compared in injured and uninjured golfers (M. Cole & P. Grimshaw, 2008; M. H. Cole & P. Grimshaw, 2008; Horton, Lindsay, & Macintosh, 2001), but these studies were not able to distinguish if the differences in muscle function resulted from the injury itself, or whether these differences in muscle function were a part of the injury mechanism.

**METHODS:**

Thirty four injury free golfers (mean = 2.28 (2.16)) enrolled at an elite golf academy were included in this study. Muscle activity from latissimus dorsi, rectus abdominis, external oblique and erector spinae muscles were recorded during a series of 10 drives. The golfers were then monitored for back injury over a six-month period.

**RESULTS:**

During that time 17 participants suffered back injuries, despite no difference in golfing performance, training load and most types of training (there was only a difference in the flexibility training between groups). At set up, the injured group dominant latissimus dorsi was more active than the uninjured groups ( $p = 0.048$ , effect size = 0.28). At impact there was an increased activation of dominant rectus abdominis ( $p = 0.052$ , effect size = 0.284) and dominant latissimus dorsi ( $p = 0.013$ , effect size = 0.232) in the injured group compared to the non-injured group. There was an overall increase in dominant rectus abdominis ( $p = 0.053$ , effect size = 0.284) and dominant latissimus dorsi ( $p = 0.019$ , effect size = 0.246) in the injury group compared to the uninjured group.

**CONCLUSION:**

We propose that the injured golfers overuse of latissimus dorsi and rectus abdominis resulted in an increased unilateral spinal compression, which made the spine more susceptible to injury. A consequence of these findings is that selective spinal muscle training may prove to be protective against back injury in competitive golfers.

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**TACKLING THE RETURN TO PLAY: INTERMITTENT HYPOXIA ACCELERATES THE REPAIR OF SKELETAL MUSCLE INJURY**

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**INTRODUCTION:**

Intermittent hypobaric hypoxia (IHH) has been widely studied and used to improve athlete's performance. Hypoxic exposure induces beneficial morphofunctional adaptations in the skeletal muscle by improving angiogenesis among other actions. Thus, the aim of this study was to assess if IHH could accelerate the muscle regeneration process after muscle injury.

**METHODS:**

After right gastrocnemius surgical injury, 32 rats were randomly assigned to two groups: CTRL, passively recovered in normoxia; and HYPO, submitted to an IHH exposure protocol (4h/day at 4,500m). Animals were euthanized in two different time points (9 and 21 days after injury). Injured (INJ) and contralateral healthy (HLT) gastrocnemius force properties (peak force, PF; tetanic force, TF in mN/g) and fatigue properties at low frequency stimulation (30 Hz) were in vivo measured. After 21 days of treatment, HIF-1 $\alpha$ , GLUT-1, VEGF, AKT and mTOR protein expression in the gastrocnemius muscle were analysed by Western Blot and histological slides were stained to measure muscle capillarity density (CD, mm<sup>2</sup>), fibre cross sectional area (FCSA,  $\mu$ m<sup>2</sup>) and fibre type proportions.

**RESULTS:**

21 days after injury, CTRL group presented significant lower force values in INJ legs as compared to contralateral HLT (PF: 43 $\pm$  12 vs 51 $\pm$  6,  $p$ = 0.049; TF: 142 $\pm$  44 vs 179 $\pm$  27,  $p$ = 0.024) and lower resistance to fatigue ( $p$ = 0.038), whilst HYPO group showed total recovery in all force parameters. Interestingly, the recovery of INJ muscles' force properties was already achieved 9 days after injury in the IHH treated group (PF: 60 $\pm$  8 vs 59 $\pm$  8,  $p$ = 0.824; TF: 222 $\pm$  23 vs 211 $\pm$  22,  $p$ = 0.227). Regarding histological features, after 21 days of hypoxic exposure, gastrocnemius muscle did not present significant changes neither in FCSA, CD, nor type proportions. No changes between INJ and HLT legs and between groups were found in VEGF, GLUT-1 and HIF-1 $\alpha$  protein expression. P-AKT/total-AKT ratio was also unchanged when comparing HLT (0.626 $\pm$  0.12 vs 0.755 $\pm$  0.20,  $p$ = 0.511) and INJ legs (0.565 $\pm$  0.15 vs 0.549 $\pm$  0.19,  $p$ = 0.944) from both groups. However, mTOR protein expression was significantly higher in HLT legs of HYPO group than in CTRL (1.345 $\pm$  0.29 vs 3.261 $\pm$  0.41,  $p$ = 0.010), while no changes were detected between INJ legs of two groups (2.148 $\pm$  0.39 vs 2.187 $\pm$  0.28). There were no changes in p-mTOR/total mTOR ratio after the hypoxic treatment.

**CONCLUSION:**

After 9 days of IHH exposure from injury, gastrocnemius muscle recovered its functional capacities, while untreated muscle still presented reduced force properties 21 days after injury. IHH treatment did not alter neither muscle morphology nor fibre type composition. HIF-1 $\alpha$  induced by hypoxia and its target proteins (VEGF and GLUT-1) did not present any changes in muscle after IHH. Since mTOR protein expression was significantly higher in HLT legs after the IHH treatment, the expression of this protein stands as one of the key factors involved in the acceleration of muscle repair process under intermittent hypoxia.

**OP-MH04 Cardiovascular health and rehabilitation****HIGH-INTENSITY INTERVAL TRAINING FOR IMPROVING BLOOD PRESSURE AND CARDIORESPIRATORY FITNESS IN HYPERTENSIVE ADULTS WITH ABDOMINAL OBESITY**

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**INTRODUCTION:**

Exercise interventions in hypertensive adults aim to reduce cardiovascular risk and improve cardiometabolic function. Stage I hypertension without chronic diseases need non-drug approaches. High-intensity interval training (HIIT) has the potential for a better cardiovascular protection effect compared to other training methods. The purpose of this study was to determine differences in blood pressure and cardiorespiratory fitness in hypertensive adults with abdominal obesity.

**METHODS:**

Forty-one inactive hypertensive adults but healthy with abdominal obesity (age: 30–45 y, BMI: 25–36 kg/m<sup>2</sup>, waist circumference: 83–109 cm) were randomized to either aerobic interval training/AIT group (n = 22) or control group (n = 19). Twenty-two hypertensive adults with abdominal obesity (age: 36.1  $\pm$  4.80 y, BMI: 29.50  $\pm$  3.09 kg /m<sup>2</sup>, waist circumference: 98.05  $\pm$  7.96 cm, systolic blood pressure (SBP): 134.02  $\pm$  3.99 mmHg, diastolic blood pressure (DBP): 86.33  $\pm$  6.63 mmHg) participated in this study. HIIT prescription was three intervals of 4 min (3x4 AIT) at 77–95 % of maximum heart rate interspersed with 3 min of active recovery at 64–76 % of maximum heart rate, three training sessions per week for 10 weeks. Cardiorespiratory fitness was measured by Bruces modified treadmill method while waist circumference measured by measuring tape. Before and after 10 weeks, the following data were obtained: blood pressure data, waist circumference, and cardiorespiratory fitness.

**RESULTS:**

Before the intervention, SBP was 134.02  $\pm$  3.99 mmHg in the aerobic group and 135.27  $\pm$  2.50 mmHg in the control group ( $p$ =0.32). DBP was 86.33  $\pm$  6.63 mmHg in the aerobic group and 88.00  $\pm$  7.82 mmHg in the control group ( $p$ =0.46). There were significant differences between the groups in the SBP ( $p$ =0.01) and DBP (0.02). High-intensity interval training reduced systolic blood pressure (8.95  $\pm$  8.39 mmHg) and diastolic blood pressure (4.49  $\pm$  6.99 mmHg). At baseline, waist circumference was 98.05  $\pm$  7.96 cm in the aerobic group and 93.50  $\pm$  7.51 cm in the control group ( $p$ =0.07). Although there were no significant differences between the groups ( $p$ =0.96), HIIT decreased waist circumference (3.78  $\pm$  3.40 cm). Cardiorespiratory fitness (VO<sub>2</sub> max) was 40.80  $\pm$  10.00 ml/kg/min in the aerobic group and 39.81  $\pm$  11.35 ml/kg/min in the control group ( $p$ =0.69). There were significant differences between the groups in the cardiorespiratory fitness level ( $p$ =0.00). Cardiorespiratory fitness increased significantly (11.94  $\pm$  7.35 ml/kg/min) with increasing exercise intensity.

**CONCLUSION:**

HIIT with lower volume (3-AIT) performed three times per week may be a time-efficient strategy to improve cardiometabolic function in inactive but otherwise healthy hypertensive adults with abdominal obesity.

## SEX DIFFERENCES IN SUBMAXIMAL EXERCISE TESTING IN CARDIOVASCULAR REHABILITATION SETTINGS

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### INTRODUCTION:

Cardiovascular rehabilitation (CR) programs improve patients' peak aerobic power ( $\dot{V}O_{2peak}$ ), a strong predictor of morbidity and mortality. Cardiopulmonary exercise testing (CPET) is the gold standard for determining  $\dot{V}O_{2peak}$ , yet is often impractical because of the cost, expertise and technological resources required. Submaximal exercise testing is not routinely performed within CR programs, but provides an alternative validated, practical and cost-effective approach to assessing  $\dot{V}O_{2peak}$ . Sex differences in the response to exercise training are well-established and may exist when examining the validity of submaximal exercise tests. This pre-post experimental study assessed sex differences in changes in  $\dot{V}O_{2peak}$  following CR as predicted by 3 submaximal exercise tests (i.e. modified Bruce treadmill, Astrand-Ryhming cycle ergometer and Chester step tests) in comparison with CPET.

### METHODS:

Adults with cardiovascular disease participated in a 12-week CR program. At baseline and 12 weeks follow-up, CPET and the 3 subsequent submaximal exercise tests were performed in a random order.

### RESULTS:

Of the 50 adults (age:  $57 \pm 11$  years; females: 23%: males: 77%) who participated, 46 completed the 12-week CR program and exercise tests. No significant differences between females and males for age ( $56 \pm 15$  vs.  $58 \pm 10$  years), body mass index ( $29.4 \pm 6.7$  vs.  $28.4 \pm 4.7$  kg/m<sup>2</sup>), blood pressure ( $118/71 \pm 13/10$  vs.  $121/74 \pm 14/9$  mmHg) or  $\dot{V}O_{2peak}$  ( $23.5 \pm 6.1$  vs.  $27.0 \pm 6.0$  mL/kg/min) were observed at baseline ( $p > 0.05$ ). In females at baseline, 75%, 67% and 33% of the treadmill, step and cycle tests were successfully completed, respectively. In females at follow-up, 60%, 70% and 40% of the treadmill, step and cycle tests were successfully completed, respectively. In males at baseline, 68%, 68% and 39% of the treadmill, step and cycle tests were successfully completed, respectively. In males at follow-up, 69%, 83% and 47% of the treadmill, step and cycle tests were successfully completed, respectively. In females, Bland-Altman plots revealed that the mean bias and limits of agreement in changes in  $\dot{V}O_{2peak}$  between CPET and the treadmill, steps and cycle tests were 1.0 mL/kg/min (12.7, -10.8), -1.4 mL/kg/min (9.6, -12.4) and -8.0 mL/kg/min (26.8, -42.7). In males, proportional bias between the change in  $\dot{V}O_{2peak}$  between CPET and the treadmill test was observed. Bland-Altman plots revealed that the mean bias and limits of agreement in changes in  $\dot{V}O_{2peak}$  between CPET and the steps and cycle tests were 2.1 mL/kg/min (16.2, -12.1) and 2.8 mL/kg/min (19.7, -14.2).

### CONCLUSION:

Given the greater number of successful tests and acceptable mean bias, the step test appears to be a valid method for assessing mean-level changes in  $\dot{V}O_{2peak}$  among both females and males in CR. Wide limits of agreement, however, limit their use to the prediction of individual-level changes. Further, larger studies are needed to confirm these findings.

## HIGH-INTENSITY INTERVAL TRAINING EXERCISE FOR AMBULATORY CARDIAC PATIENTS: PRELIMINARY RESULTS

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### INTRODUCTION:

Recent literature reinforces that cardiac rehabilitation based on exercise training induces several beneficial effects on cardiovascular functional capacity, quality of life, risk factors modification, psychological profile, hospital readmissions, and mortality [1]. However, the most effective exercise intensity for cardiac patients remains doubtful [2]. High-intensity Interval Training (HIIT) has recently been prescribed for cardiac patients, showing faster and effective results [3]. This study aimed to compare the pre- and post-intervention effects of an ambulatory HIIT cardiac rehabilitation program.

### METHODS:

Five post-myocardial infarction patients (aged  $60.4 \pm 7.3$ ) engaged in a six weeks long HIIT exercise program, applied after medical discharge. Participants were assessed for body composition (waist circumference), sedentary behavior (tri-axial accelerometer), cardiorespiratory fitness (six-minute walk test), and biochemical markers (total cholesterol, triglycerides, and insulin). HIIT exercise sessions consisted of four four-minute high-intensity intervals, stimulating 85-95% of Maximal Heart Rate (MHR) followed by active recovery at 70% of MHR for a total of 20 minutes. The protocol will include a warm-up of 10 minutes at low moderate intensity (50-70% of MHR) and a 3 to 5-minute calm return period was performed at 50% of MHR. Differences between pre- and post-intervention were tested through Cohen's d effect size (90% confidence intervals) in all the measures.

### RESULTS:

Present HIIT intervention promoted beneficial effects in all the outcomes, showing to have a moderate effect on waist circumference ( $d=0.6$ ) and insulin ( $d=0.6$ ), a large effect on sedentary behavior ( $d=1.6$ ) and triglycerides ( $d=1.7$ ), and a very large effect on cardiorespiratory fitness and total cholesterol ( $d=2.4$  and  $d=2.2$ , respectively).

### CONCLUSION:

This study results, despite being preliminary results, reinforced the effectiveness of HIIT exercise for myocardial infarction patient's rehabilitation. Moreover, it proved that a short-time intervention based on HIIT exercise promoted beneficial effects on cardiovascular disease's main risk factors.

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### IS IDEAL CARDIOVASCULAR HEALTH ASSOCIATED WITH ARTERIAL STIFFNESS, INFLAMMATION AND PHYSICAL FITNESS IN WOMEN WITH SYSTEMIC LUPUS ERYTHEMATOSUS?

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#### INTRODUCTION:

The American Heart Association described a set of 7 cardiovascular (CV) health metrics to develop the new concept of ideal cardiovascular health (ICH) (1). ICH has been reported as strong predictor of CV mortality and highlights the importance of primordial prevention in the general population (2). Systemic lupus erythematosus (SLE) is an autoimmune multisystemic disease in which atherogenic CV diseases are the main cause of mortality (3). Understanding the extent to which the concept of ICH is associated with arterial stiffness, inflammation and physical fitness (i.e. all relevant markers of CV disease and mortality) is of clinical interest. The aim of the present study was to examine the association of ICH with arterial stiffness, inflammation, and physical fitness in SLE women.

#### METHODS:

This cross-sectional study included 76 women with SLE. ICH was created as meeting a minimum of 4 ideal levels out of the following 7 components: smoking status, body mass index, physical activity, healthy diet, blood pressure, cholesterol, and glucose. Arterial stiffness was assessed by pulse wave velocity (PWV) and inflammation by plasma C-reactive protein (CRP) level. Cardiorespiratory fitness was assessed through the 6 minutes walk test (6MWT) and the Siconolfi step test, muscular strength through the 30-s chair stand test and the handgrip strength tests, and flexibility through the back-scratch test. Between-groups comparisons in PWV, CRP, and fitness between participants with ICH status and non-ICH status were assessed with analysis of covariance (ANCOVA) with age, SLEDAI (assessing the degree of disease activity), SDI (assessing of the degree of tissue damage), and disease duration as covariates.

#### RESULTS:

In comparison with participants with no ICH, participants with ICH presented lower PWV (mean difference 0.40 m/s, 95% CI 0.17 to 0.63,  $p=0.001$ ), and higher cardiorespiratory fitness [assessed by 6MWT (mean difference 43.85 m, 95% CI 5.01 to 82.68,  $p=0.028$ )]. Although non-significantly, participants with ICH presented lower CRP values (mean difference 1.05 mg/l, 95% CI -0.19 to 2.29,  $p=0.096$ ), higher estimated VO<sub>2</sub>max in the Siconolfi test (mean difference 1.30 ml/kg/min, 95% CI -0.02 to 2.63,  $p=0.054$ ), and higher back-scratch values (mean difference 4.12 cm, 95% CI -0.26 to 8.51,  $p=0.065$ ) compared to those with non-ICH.

#### CONCLUSION:

ICH was associated with lower arterial stiffness and higher cardiorespiratory fitness in women with SLE. We also observed that participants with ICH presented lower inflammation and higher flexibility, although these results need to be confirmed or contrasted in future prospective research including clinical trials.

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### THE EFFECT OF THREE-YEARS OF AEROBIC EXERCISE ON HIGH-DENSITY LIPOPROTEIN CHOLESTEROL IN OLDER ADULTS

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#### INTRODUCTION:

Dyslipidemia, is one of the major risk factors for cardiovascular disease (CVD), which is the leading cause of death in older adults. Pharmacological treatments have not proven to be as efficient in increasing high-density lipoprotein cholesterol (HDL-C) as they are at decreasing low-density lipoprotein cholesterol (LDL-C). Although exercise has been shown to induce favorable changes in both HDL-C and LDL-C in younger adults, the effects of exercise on HDL-C in older adults are unclear. The aim of this study was to examine the effect of three-year of exercise on HDL-C in older men and women.

#### METHODS:

A total of 1567 individuals (790 women) were included and randomized to either 3 years of two weekly sessions of high-intensity interval training (HIIT) (10 min warm-up followed by 4x4 min intervals at ~90% of peak heart rate) or moderate-intensity continuous training (MICT) (50 min of continuous work at ~70% of peak heart rate) or, to a control group (CON) that followed the national recommendations for physical activity. Serum HDL-C was measured using standard procedures at St.Olavs Hospital, Norway. Linear mixed models were used to determine within- and between-group differences over time.

#### RESULTS:

Men significantly improved HDL-C in CON (0.040 mmol/L,  $p=0.007$ ) and HIIT (0.063 mmol/L,  $p=0.011$ ) after three years of intervention. Women, who followed the prescribed exercise, had a tendency to improve HDL-C after three years of HIIT (0.07 mmol/L,  $p=0.063$ ).

#### CONCLUSION:

Men improved HDL-C after three years of HIIT and by following the national recommendations for physical activity. In women there was a tendency for better improvements after HIIT. Thus, intensity seems to be an important factor in improving HDL cholesterol in older adults.

**THE INFLUENCE OF GENDER ON BLOOD PRESSURE BENEFITS OF NON-TRADITIONAL EXERCISE MODES AMONG ADULTS WITH HYPERTENSION: A META-REVIEW**

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**INTRODUCTION:**

The American College of Sports Medicine (PMID:31095088) recently stated that the evidence supporting the antihypertensive effects of non-traditional exercise modes (e.g., Tai Chi and Yoga) is promising. Still, information is lacking on whether gender moderates the blood pressure (BP) benefits of these and other non-traditional exercise types. Thus, we assessed the influence of gender on the BP response to non-traditional exercise modes in adults with hypertension.

**METHODS:**

We included randomized controlled trials (RCT) published in meta-analyses (MAs) that: a) assessed the impact of non-traditional exercise interventions on BP (PMID:23986780; PMID:30792067; PMID:27390986; PMID:28914562; PMID:29371223); b) were published in English within the past 20 years; c) included adults with systolic BP (SBP) >140 mmHg and diastolic BP (DBP) > 90 mmHg; and d) had a non-exercise control group. We contacted authors of the primary level RCTs to request data for men and women separately when they reported the total sample only. We then: 1) calculated the overall RCT-level mean difference effect sizes to quantify the antihypertensive effects of exercise versus control; 2) removed outliers beyond the 95%CI; and 3) performed gender subgroup analysis and meta-regression with exercise mode. Statistical analyses were performed with “R” software.

**RESULTS:**

Sixteen RCTs, with mean duration of 15 weeks, qualified for the meta-review. The non-traditional exercise interventions included Tai Chi (3/4 [k studies/N arms]), Yoga (2/2), dance (2/4), aquatic exercise (3/3), and recreational soccer (6/6), and a total of 1020 participants (220 men; 800 women) with a baseline SBP of 151/89 mmHg and DBP of 149/88 mmHg (p=0.24), with 53 and 68 years of age for men and women, respectively (p=0.91). Only 8 studies reported antihypertensive medication use, with a total of 197 out of 364 participants on medication. Overall, the interventions decreased SBP by 7.1 mmHg (95%CI: -7.9 to -9.5 mmHg; I2=71%) and DBP by 4.2 mmHg (95%CI: -2.2 to -6.2 mmHg; I2=84%) versus control. After removing outliers (2 arms for SBP [50 women;7 men]) and 1 arm for DBP (148 women), exercise interventions decreased SBP by 6.0 mmHg (95%CI: -4.0 to -7.8 mmHg; I2=37%) and DBP by 3.7 mmHg (95%CI: -2.3 to -5.2 mmHg; I2=43%) versus control.

Subgroup analysis showed no significant differences between genders for the changes in SBP (p=0.26; men: -4.6 mmHg, 95%CI: -7.4 to -1.7 mmHg; women: -6.6 mmHg, 95%CI: -8.9 to -4.4 mmHg) and DBP (p=0.58; men: -4.2 mmHg, 95%CI: -5. to -2.5 mmHg; women: -3.4 mmHg, 95%CI: -5.7 to -1.1 mmHg). The exercise mode did not influence the magnitude of the BP response (p=0.24 (SBP); p=0.32 (DBP)).

**CONCLUSION:**

The available evidence among adults with hypertension, suggests that the BP benefits of a variety of non-traditional exercise modes are similar for men and women.

This work is supported by national funding through the Portuguese Foundation for Science and Technology, I.P., under project UID/DTP/04045/2019.

**WALKING PERFORMANCE AND CARDIOVASCULAR EFFECTS OF LOAD PROGRESSION DURING A 6-MONTH SUPERVISED EXERCISE PROGRAM IN PERIPHERAL ARTERIAL DISEASE**

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**INTRODUCTION:**

In Peripheral Arterial Disease (PAD), the discomfort associated with intermittent claudication (IC) reduces physical fitness and walking performance [1]. Exercise has a positive effect on walking performance [2,3], however, the load progression effects have been poorly studied. This study aims to analyze the walking performance and cardiovascular response of walking intensity progression over a supervised exercise program (SEP).

**METHODS:**

A sample of 10 volunteer men with PAD (stage II, Fontaine classification) and an ankle-brachial index <0.90, performed 6 months of SEP. The sessions included 40-minute treadmill walking followed by 3 lower-limb resistant exercises (1-3 sets, 15 repetitions), 3 times a week. The work-rest cycle was used (i.e., to interrupt walking when moderate/severe pain arises and restart walking after total pain relief). The load progression was manipulated in an individual and gradual way, through grade and speed treadmill increases, using IC pain level. The claudication onset distance (COD), claudication onset time (COT), absolute claudication distance (ACD), absolute claudication time (ACT), number of pauses (NP), rate perceived exertion (RPE), IC pain level and percent of heart rate reserve (%HRR) were evaluated. Initial (IN), intermediate (IT) and final (FN) loads of treadmill walking were compared, and the first and last session within each load were compared too.

**RESULTS:**

The treadmill load increase promoted a variation of 24±3% to 37±11% of %HRR between IN and FN. The load’s progression promoted significant differences in ACT increase between IN and IT (1718±475 and 2335±184 seconds, p=0.012), between IN and FN (1718±475 and 2284±196 seconds, p=0.012) and, in ACD increase between IN and IT (1527±422 and 2309±237 meters, p=0.005), and between IN and FN (1527±422 and 2397±394 meters, p=0.005). Within each load, there were significant differences throughout the first and last exercise session in the IN in COT (521±535 and 990±719 seconds; p=0.008), COD (463±475 and 880±639 meters; p=0.008), ACT (1253±795 and 2100±424 seconds; p=0.027), ACD (1114±706 and 1867±377 meters; p=0.027) and NP (1.1±1.4; 0.1±0.3; p=0.041).

**CONCLUSION:**

Over the 6-months, the magnitude of load progression used in PAD participants represented a very light/light walking intensity. The increase of walking intensity did not promote differences in COD, COT, IC level, NP and RPE but improve ACD and ACT. Within loads, a greater magnitude of walking performance occurred in IN.

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### ENDOTHELIAL FUNCTION MEASURED BY DIGITAL THERMAL MONITORING OF VASCULAR REACTIVITY BEFORE AND AFTER MARATHON

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#### INTRODUCTION:

Endurance exercise induces an acute transient vascular damage characterized by apoptotic endothelial- and thrombocyte-derived micro-particles that may contribute to post-exertional cardiovascular complications as postural hypotension. Digital thermal monitoring (DTM) as a simple noninvasive method to measure vascular reactivity correlated with cardiovascular disease [1]. The aim of this study was to determine endothelial function of marathon runners before and after race measure by DTM and associate to Blood Pressure (BP).

#### METHODS:

Participated in this study twenty-two male amateur runners (age,  $44 \pm 1$  years; % of fat mass,  $19 \pm 1\%$ ; body mass index,  $23 \pm 0.45$  kg/m<sup>2</sup>; time on 10 km race,  $47 \pm 1.6$  minutes). We recorded the fingertip temperature of right arm during 10 minutes at ambient temperature. The cuff occlusion was performed during 5-minute with 30mmHg above systolic BP (SBP) of the right arm. After the cuff release, we recorded 5 minutes to observe the slope of temperature raise of the reactive hyperemia. We evaluated SBP and diastolic BP (DBP), right finger temperature before occlusion (T0), before cuff release (T5), maximum temperature (Tmax), temperature rebound (Tmax-T0) and the slope of temperature curve to reach Tmax after cuff release. The difference between maximum temperature rebound and the temperature before cuff release (zero reactivity curve) indicate the vascular reactivity index (VRI).

#### RESULTS:

The marathon runners have good vascular reactivity index (VRI  $>2$  oC) before and after race. The T0, Tmax, and T5 were higher after marathon race as expected due excess post-exercise oxygen consumption. However, marathon race induced impairment on VRI from  $5.4 \pm 0.4$  oC to  $3.9 \pm 0.2$  oC and slope of right finger temperature curve from  $2 \pm 0.25$  to  $0.9 \pm 0.2$  indicating peripheral vascular damage. In addition, we observed a negative correlation between SBP before marathon with Tmax after marathon ( $r=-0.48$ ,  $p=0.027$ ) as well as a negative correlation between DBP before marathon with TR before and VRI after race ( $r=-0.5$ ,  $p<0.012$ ). We suggest that lower vascular response after marathon was observed in runners with higher BP at rest. In the other hand, SBP and DBP after marathon have a positive correlation with T0 ( $r=0.50$ ,  $p=0.017$ ;  $r=0.57$ ,  $p=0.006$ , respectively), T5 ( $r=0.46$ ,  $p=0.031$ ;  $r=0.53$ ,  $p=0.011$ ), Tmax ( $r=0.57$ ,  $p=0.006$ ;  $r=0.75$ ,  $p=0.00007$ ), slope (SBP,  $r=0.43$ ,  $p=0.046$ ) and VRI (DBP,  $r=0.54$ ,  $p=0.009$ ) before marathon. We also suggest that runners with lower vascular response before race may have low BP and higher risk of postural hypotension after the race

#### CONCLUSION:

Marathon race seems to induce endothelial damage measured by DTM of vascular reactivity and may be a meaningful physiological toll to avoid post-exertional cardiovascular complications as postural hypotension.

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## OP-MH05 Physiotherapy - Rehabilitation

### WHOLE BODY VIBRATION TRAINING DURING ALLOGENEIC HEMATOPOIETIC CELL TRANSPLANTATION – THE EFFECTS ON PATIENTS PHYSICAL CAPACITY

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#### INTRODUCTION:

An allogeneic hematopoietic cell transplantation (alloHCT) is usually associated with hospitalization lasting at least four weeks. Thus, patients undergoing alloHCT experience a considerable decline in physical performance - maximum oxygen consumption and muscular performance in particular - and psycho-social capacity, especially quality of life (QoL). Although, there are already studies investigating the effect of exercise interventions during alloHCT, it remains unclear how cardiopulmonary fitness and muscle strength can both be maintained most efficiently. Since whole body vibration (WBV) is known to efficiently stimulate the neuromuscular system and enhance cardiorespiratory fitness and muscle strength in frail individuals, we hypothesized that WBV would maintain various physical and psychological capacities in patients during alloHCT.

#### METHODS:

71 patients were randomly allocated 1:1 to either an intervention group (IG) doing WBV or an active control group (CG) doing mobilization exercises five times per week at least 20min each session. Stratified randomization was based on patients sex and conditioning chemotherapy protocol. We determined peak oxygen consumption (VO<sub>2</sub>peak) and maximum power during maximum cardiopulmonary exercise test, maximum strength via isokinetic measurement, functional performance on a force plate, body composition via air displacement plethysmography system as well as bioelectrical impedance analysis and quality of life (QoL) and fatigue via questionnaires. Tests were carried out before conditioning therapy, at hospital discharge and at day  $\pm 180$  (follow-up).

#### RESULTS:

As 18 patients did not participate in post-intervention assessment and follow-up data from 9 patients was not collectible, per-protocol (PP) analysis of 44 patients is presented. During hospitalization, WBV maintained maximum strength, height and power output during jumping, as well as reported QoL, physical functioning, and fatigue level compared to mobilization. At follow-up, relative VO<sub>2</sub>peak ( $p=0.035$ ) and maximum power ( $p=0.011$ ), time and power performing chair-rising-test ( $p=0.022$ ;  $p=0.009$ ) and reported physical functioning ( $p=0.035$ ) significantly increased in the IG, while fatigue decreased ( $p=0.005$ ). CGs body cell mass and phase angle had significantly decreased at follow-up ( $p=0.002$ ;  $p=0.004$ ).

#### CONCLUSION:

WBV presents an effective exercise method for patients undergoing alloHCT to preserve maximum strength, functional performance, and QoL, and to prevent worsening fatigue during hospitalization. Furthermore, WBV seems to facilitate accelerated physical recovery concerning the cardiorespiratory system, body cell mass, and phase angle.

### ELASTOGRAPHIC EVALUATION OF SUPRASPINATUS MUSCLE FORCE AFTER ROTATOR CUFF REPAIR

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#### INTRODUCTION:

Rotator cuff tear is common in musculoskeletal disorders, and causes shoulder pain and dysfunction, frequently resulting in rotator cuff repair as a surgical treatment. After rotator cuff repair, magnetic resonance imaging and B-mode ultrasonography were used to assess the features of the repaired rotator cuff. These conventional modalities, however, grasp the morphological features and cannot identify the functional ones. Ultrasonic shear wave elastography is a promising imaging technique to assess regional shear modulus of a muscle reflecting the functional features of muscle, i.e. surrogate of muscle force, and was utilized for the supraspinatus, one of the rotator cuff muscle. Comprehending the muscle force of the supraspinatus after rotator cuff repair is meaningful for the postoperative management and rehabilitation. The purpose of this study was to investigate the effect of postoperative day on the supraspinatus force, and to compare the supraspinatus force between repaired and control sides.

#### METHODS:

Twenty-six patients who had received rotator cuff repair participated. Using shear wave elastography, the shear modulus of the supraspinatus was measured in both repaired and contralateral control sides of the patients' shoulders. The images of the supraspinatus were acquired under the two conditions. At first, the patients' arm was passively held at 30° of shoulder abduction, in which measured shear modulus was defined as passive force, and then they held their arm at the same angle by themselves, in which measured shear modulus was defined as total force. As, additionally, focusing on the capacity of how much the patients activate voluntarily supraspinatus, we calculated the difference between the passive force and the total force, herein defined as active force. To test whether the passive, active, and total forces of the supraspinatus in the repaired side changes over time, we applied quadratic regression analysis with postoperative day as independent variable. Each of the supraspinatus force was compared between the repaired and the control sides.

#### RESULTS:

The regression analysis showed that the postoperative day did not significantly relate to all of the supraspinatus muscle force. In the comparisons between the repaired and the control sides, there was no significant difference in the active force of the spraspinatus muscle. However, the passive and total forces of the supraspinatus in the repaired side were significantly lower than those in the control side.

#### CONCLUSION:

The passive force of the supraspinatus in the repaired side did not recover with postoperative day, and the passive was still lower compared to that in control side, consequently the total force was also lower. Interestingly, there was no difference of the active force between the two sides. These results imply that albeit the mechanical property of the supraspinatus did not fully recover in the repaired side, the central motor system worked and sent the motor command to the muscle as usual.

### ISOLATED CERVICAL EXTENSION RESISTANCE EXERCISE IMPROVES CLINICAL SYMPTOMS AND ISOMETRIC NECK EXTENSION STRENGTH IN PATIENTS WITH CERVICAL DISC HERNIATION AND RADICULOPATHY

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#### INTRODUCTION:

Neck pain represents a major health problem and economic burden in modern societies. Results from recent studies indicate that patients' cervical extensor muscles exhibit morphological changes such as atrophy and fatty infiltration (Schomacher & Falla, 2013). Treatments that include isolated cervical extension resistance exercise (ICEX) have shown promising outcomes in patients with neck pain (Bronford et al., 2001). However, it remains unclear if this method can also be used to treat patients with severe conditions such as cervical disc herniation. The aim of this study was therefore to evaluate clinical effects and changes in muscle strength of ICEX for this patient group.

#### METHODS:

In this case series 59 consecutive patients (26 women, 33 men; mean age 50.1, range 28-76 years) with cervical disc herniation and radiculopathies in head, shoulder, arms or chest underwent a 9 week rehabilitation program including one set (12-15 repetitions) of machine based ICEX (18 sessions, 2 times per week). Prior to the study all patients had tried other conservative treatments without any success. Clinical examination and evaluation of MR imaging was performed by an orthopedic consultant. The range of motion (ROM) during ICEX was limited in flexion (mean: 81°) to reduce pressure onto the discs during movement. ROM and weights were constantly adapted to the patients' symptoms. Before and after the intervention program isometric cervical extension strength was tested. Pain/discomfort, mental suffering and satisfaction rates were measured via Numeric Pain Rating Scale (NRS, 0-10). The achieved rehabilitation progress was also rated in % (0-100, 0% = no improvement, 100%=completely free of pain).

#### RESULTS:

Overall, 54/59 patients (91.5%) reported a reduction of clinical symptoms: 17 patients (28.8%) were free of symptoms, 25 patients (42.4%) reported a marked reduction of complaints, 12 patients (20.3%) had light improvements, for 5 patients (8.5%) there was no change. NRS scores for pain and discomfort decreased on average from 4.2 (±2.2) to 2.0 (±1.7) ( $p<0.001$ ), mental suffering from 5.4 (±2.5) to 2.4 (±2.4) ( $p<0.001$ ). Satisfaction rate was rated on average 7.7 and rehabilitation progress 72.9%. Isometric cervical extension strength increased on average 49.6% (median 39.4%). Patients that had gains in isometric strength higher than 39% experienced a better rehabilitation progress (81.4% vs. 66.2%;  $p<0.05$ ) than those with lower strength increase and there was also a trend towards higher satisfaction (8.4 vs. 7.3;  $p=0.09$ ).

#### CONCLUSION:

The results indicate that increasing the level of cervical extension strength through ICEX treatment can reduce symptoms in patients with diagnosed cervical disc herniation and radiculopathy. Thus, ICEX may be a promising tool for potentially avoiding cervical spine surgeries. Its clinical potential should be further evaluated in future studies.

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## CONSERVATIVE TREATMENT OF SUBACROMIAL IMPINGEMENT SYNDROME - A RCT COMPARING THE EFFECTS OF TWO DIFFERENT UNSUPERVISED, SINGLE-EXERCISE, HOME-BASED STRENGTHENING TRAININGS

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### INTRODUCTION:

Conservative treatments (e.g., manual therapy) and especially strengthening exercises of the shoulder muscles, are effective means to reduce shoulder pain/function and improve physical performance (e.g., range of motion, muscular strength) in patients with subacromial impingement syndrome (SIS) (1). However, those training regimes usually include multiple exercises and require the presence of an expert (e.g., physical therapist). An unsupervised, single-exercise, home-based strengthening training of the rotator cuff muscles may represent a promising alternative to reduce symptoms of SIS (2), time- and cost-effectively. The present study aimed to compare the effectiveness of two different unsupervised, single-exercise, home-based strengthening exercise regimes in SIS patients.

### METHODS:

Fifty-six adult SIS-patients ( $53.3 \pm 7.3$  years) were randomly assigned to either a passive control (CON;  $n=20$ ), a traditional training (TRA;  $n=19$ ), or an alternative training (ALT;  $n=17$ ) group. Both training groups conducted an eight weeks progressive resistance training using elastic bands either with (ALT) or without (TRA) employing a device (Schulterhilfe®) supporting the arms in abducted position during the exercise. Pre- and post-intervention measures of shoulder pain/function (i.e. SPADI) and physical performance (i.e., shoulder flexibility, maximal isometric muscle strength, strength endurance) were assessed.

### RESULTS:

Significant Test  $\times$  Group interactions were found for most of the investigated variables. Post-hoc analysis revealed significant training-related improvements for measures of shoulder pain/function (+28-55%,  $p < .004$ -.001,  $d = 0.64$ -0.98), shoulder flexibility (+5-38%,  $p < .207$ -.001,  $d = 0.27$ -1.13), maximal isometric muscle strength (+22-42%,  $p < .001$ ,  $d = 0.28$ -0.88), and strength endurance (+14-55%,  $p < .012$ -.001,  $d = 0.66$ -0.94), all in favor of the ALT-group.

### CONCLUSION:

Compared to the passive CON-group, both unsupervised, single-exercise, home-based training regimes significantly improved measures of shoulder pain/function and physical performance in SIS-patients. However, larger and more frequent effects were found in favor of the ALT- compared to the TRA-group. Therefore, an unsupervised, single-exercise, home-based strengthening training of the rotator cuff muscles using the shoulder device seems to be a time- and cost-effective alternative/supplement to traditional therapy (e.g., surgery, physical therapy) in order to mitigate symptoms of SIS.

### References

- 1) Haik et al., Br J Sports Med, 2016.
- 2) Littlewood et al., Clin Rehabil, 2016.

### Funding

This work was funded by the AktiFlex-Produkte KG (Heusenstamm, Germany)

## PHYSICAL PERFORMANCE & PHYSICAL FUNCTION ADAPTATIONS FOLLOWING A 12-WEEK MIXED TRAINING IN MIDDLE-AGED AND OLDER HIV-POSITIVE MEN: DOES HIV DURATION MATTER ?

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### INTRODUCTION:

Aging is associated with declines in physical performance and physical function, which seems to be accentuated with HIV since this disease is considered as accelerating aging process. Exercise is a good way to fight against these harmful effects of aging. However, the impact of HIV and more specifically HIV duration (biological aging) on exercise adaptation has not yet been studied.

We aim to investigate the effect of a 12-week mixed training (i.e. High Intensity Interval Training (HIIT) mixed with power training (PT)) on physical performance and physical function in middle-aged and older HIV-positive men, according to HIV duration.

### METHODS:

Among 30 participants with history of HIV, 25 men completed the exercise intervention, and were divided a-posteriori in 2 groups according to their VIH duration (0:  $<20$  yrs ( $n=12$ ; yrs:  $12.2 \pm 4.7$ ) vs. 1:  $\geq 20$  yrs ( $n=13$ ; yrs:  $24.7 \pm 6.3$ );  $p < 0.0001$ ). Participants followed a 12-week intervention, 3 times/week, 45min/session. HIIT lasted 15 min on elliptical device and cycles were divided as follow: 30s at an intensity  $> 80\%$  of the Max Heart Rate (Borg  $> 17$ ) followed by 1 min 30 of active recovery (Borg: 12-15). PT lasted 25 min and included 2 sets of 12 repetitions (80% of the 1-Repetition Maximum) in 4 specific muscles (hamstrings, pectorals, quadriceps, and latissimus dorsi) at tempo 1-0-2-1. Grip strength (Jamar® dynamometer), lower limbs muscle power (leg power rig®), body composition (Fat (FM) and Fat-free (FFM) masses; DXA) and muscle composition (qPCT) but also performance on the 4-m (normal speed, fast speed and dual task) and 6-min walking tests were assessed pre and post intervention. Non-parametric independent t-tests were used to compare the outcomes at baseline and the changes between groups. Paired t-tests were used to compare the intervention effect within group.

### RESULTS:

Surprisingly, even if no difference in chronological age is observed (yrs, 0:  $51.6 \pm 6.4$  yrs vs. 1:  $54.9 \pm 5.3$  yrs), the HIV $<20$  yrs group have significantly lower grip strength (Kg, 0:  $34.4 \pm 6.9$  vs. 1:  $41.1 \pm 8.1$ ,  $p=0.039$ ) and leg power (W, 0:  $169 \pm 65$  vs. 1:  $239 \pm 93$ ,  $p=0.04$ ) but also higher appendicular FM (%), 0:  $53 \pm 19$  vs. 1:  $35 \pm 22$ ,  $p=0.038$ ) and gynoid FM (%), 0:  $34 \pm 10$  vs. 1:  $22 \pm 14$ ,  $p=0.035$ ) than HIV $>20$  group. Following the intervention, all parameters improved significantly in both groups. However, no significant change difference between groups was observed.

### CONCLUSION:

This study suggests that HIV duration does not accelerated physical aging. In addition, exercise appears to be effective in HIV-positive men whatever HIV duration.



## ISOLATED LUMBAR EXTENSION RESISTANCE EXERCISE REDUCES CLINICAL SYMPTOMS AND INCREASES ISOMETRIC EXTENSION STRENGTH IN PATIENTS WITH RADICULOPATHY AND LUMBAR DISC HERNIATION

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### INTRODUCTION:

Treatment of pain conditions in the lumbar spine region can be challenging especially when patients suffer from radiculopathy originating from lumbar disc herniation. Recent studies have shown that paraspinal muscle atrophy and fatty infiltration are common features in these patients (Goubert et al., 2017). Selectively strengthening these muscles via machine based isolated lumbar extension resistance exercise (ILEX) has shown good clinical outcomes for patients with unspecific low back pain (Steele et al., 2015). However, it is unknown if this method can be used to also treat patients with lumbar disc herniation.

### METHODS:

In this case series 168 consecutive patients (110 men, 58 women; mean age 36.5, range 16-50 years) with lumbar disc herniation and radiculopathy (pain and/or numbness) in pelvis, buttock or legs underwent a 9 week rehabilitation program including one set (12-15 repetitions) of machine-based ILEX (18 sessions, 2 times per week). All patients had tried other conservative treatments before without any success. Prior to the study clinical examination and proper evaluation of MR imaging was performed by an orthopaedic consultant. During the ILEX training the range of motion (ROM) was limited in flexion (39°). Weights and ROM were constantly adapted to the patients' symptoms. Provoking full muscle exhaustion with final ROM was achieved in sessions 9-18. Before and after the study lumbar extension strength was tested using an isometric strength test. Pain/discomfort, mental suffering and satisfaction rates were measured via Numeric Pain Rating Scale (NRS, 0-10, 0=no pain). Achieved rehabilitation progress was stated in % (0-100, 100%=completely pain free).

### RESULTS:

Results: For 162/168 patients (96.4%) there was a reduction of clinical symptoms after 18 sessions: 71 patients (42.3%) were free of symptoms, 75 patients (44.6%) had a marked improvement, 16 patients (9.5%) had light improvement, for 6 patients (3.6%) there was no change, no patient had a worsening of symptoms. Pain and discomfort (NRS) decreased on average from 4.2 ( $\pm 1.5$ ) to 1.9 ( $\pm 1.5$ ) ( $p < 0.001$ ), mental suffering from 5.9 ( $\pm 2.3$ ) to 2.4 ( $\pm 2.0$ ) ( $p < 0.001$ ). Satisfaction rate was on average 8.5 and rehabilitation progress was rated 78.9%. Isometric lumbar extension strength improved on average 35.7%. Age, pain duration, affected disc and amount of strength increase did not significantly affect the outcome. Patients with high pain symptoms at the beginning of the therapy had worse outcomes than patients with lower pain levels.

### CONCLUSION:

Discussion: The results of the study indicate that ILEX training with limited ROM strengthening the paraspinal muscles can reduce pain and radiculopathy in patients with diagnosed lumbar disc herniation. Thus, ILEX is a promising conservative method and can potentially avoid surgeries and improve post-operative results.

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## KINEMATICAL AND CLINICAL DIFFERENCES BETWEEN A CRUCIATE-RETAINING AND POSTERIOR-STABILIZED KNEE PROSTHESIS DURING A SIT TO STAND MOTOR TASK

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### INTRODUCTION:

Total knee arthroplasty (TKA) is the gold standard for the treatment of advanced knee osteoarthritis. Several TKA designs have been developed trying to obtain the best knee joint stability with functional improvement. Two of the most used designs are Cruciate-Retaining (CR) and Posterior-Stabilized (PS). Nevertheless, debate on correlation between knee kinematics and patients' satisfaction is still open. The aim of this study was to compare the in vivo knee kinematics of a PS and a CR TKA design, and the respective patients' clinical outcomes.

### METHODS:

A cohort of 72 patients (70.2 $\pm$ 8 years) was evaluated at minimum 9 months follow-up after surgery. PS design was implanted in 38 patients, while CR design was implanted in 34 patients. The clinical evaluation was carried out through the Knee Society Score Clinical (KSS-C). Dynamic Roentgen Stereophotogrammetric Analysis (RSA) tool was used for the in-vivo kinematical analysis while patients performed a sit-to-stand motor task. Kinematic quantitative data for each patient were calculated (Grood and Suntay decomposition): Internal-External rotations, Anterior-Posterior (AP) translations, Low-Point contact areas of the femur with respect to the tibia during knee flexion. Statistically significant differences were assessed using the t-test.

### RESULTS:

During sit to stand, the PS femoral component performed an anterior translation of 7.87 mm (from -7.48 $\pm$ 3.9 mm to 1.26 $\pm$ 2.9 mm) from 80° to 20° of knee flexion and a posterior translation of 1.25 mm (from 1.26 $\pm$ 2.9 mm to 0.01 $\pm$ 2.4 mm) from 20° of flexion to full extension. The CR femoral component performed an anterior translation of 4.1 mm (from -3.51 $\pm$ 3.0 mm to 0.99 $\pm$ 2.3 mm) from 80° to 20° of knee flexion and a posterior translation of 1.1 mm (from 0.99 $\pm$ 2.3 mm to -0.11 $\pm$ 1.7 mm) from 20° of flexion to full extension. The femoral starting position of CR design was significantly more anterior respect to the PS design ( $p < 0.002$ ) from 80° to 65° of knee flexion. Regarding clinical scores, four patients out of thirty-eight (8%) of PS design group and nine patients out of thirty-four (26%) of CR design group reported a poor KSS-C score (<70).

### CONCLUSION:

The most important finding of the present study was that the femoral component of CR TKA at 80° of knee flexion had a significantly more anterior position with respect to the PS TKA. This can be due to the geometry of the femoral component, which, respect to the PS design, does not have the box for the cam of the inlay. Posterior Cruciate Ligament alone could not be sufficient to guarantee complete AP stability. This difference could explain the highest percentage of unsatisfied patients (26%) in term of pain in CR group. In a recent study was found that a more-anteriorly located femur was present in patients with lower clinical score and biomechanically this may limit the knee extension mechanism. Further studies on a bigger sample are needed to evaluate the impact of different muscular activity on kinematics and clinical results.

## RELATIVE AND ABSOLUTE RELIABILITY OF SHOULDER RANGE OF MOTION AND ISOKINETIC PEAK TORQUE IN WOMEN WITH PERSISTENT PAIN FOLLOWING BREAST CANCER TREATMENT. A TEST RE-TEST STUDY

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### INTRODUCTION:

Range of motion and strength levels are commonly used for evaluating shoulder function among e.g. breast cancer survivors (BCS) (1). In particular, shoulder abduction and external rotation are affected in this population (2). However, little is known on the test-retest reliability of these measures in BCS with persistent pain. The purpose of this study was to assess the test-retest reliability of shoulder range of motion and strength in BCS and matched controls.

### METHODS:

Forty two women consisting of 21 BCS and 21 asymptomatic controls matched for age and body mass index participated in three experimental sessions (A; Familiarization, B; Test, C; Re-test) separated by approximately one week. Active range of motion and isokinetic peak torque were collected during session A, B and C. Active range of motion was measured with a goniometer for supine shoulder flexion, supine horizontal shoulder adduction/abduction, seated shoulder abduction, and supine internal/external shoulder rotation with 90° abduction of the upper arm. Isokinetic peak torque was measured during reciprocal repetitions at 60°/sec for the same positions. Following a brief warm up of general stretching, participants performed a set of 10 repetitions with progressive intensity, followed by a maximal set of five maximal repetitions with a 2-minute intermediate rest period. Mean peak torque was calculated at a fixed joint angle for the last four repetitions and normalized to fat free mass (FFM) estimated through segmental bioelectrical impedance measurement. Test-retest reliability (ICC<sub>2,1</sub> for absolute agreement), standard error of measurement (SEM) and minimum detectable change (MDC) were calculated using the measurements performed at session B and C. The reliability coefficients were interpreted according to Landis and Koch (3).

### RESULTS:

ICC's for both groups were "substantial" to "almost perfect", ranging from 0.66-0.97 for active range of motion and 0.62-0.92 for isokinetic peak torque. SEM values for active range of motion ranged from 3.0 to 7.5 ° and from 1.2 to 4.0 °, while MDC ranged from 8.4 to 20.8 ° and from 3.3 to 11.1 ° for patients and controls respectively. SEM values for isokinetic peak torque ranged from 0.03 to 0.07 Nm/kg FFM and from 0.01 to 0.06 Nm/kg FFM, while MDC ranged from 0.09 to 0.19 Nm/kg FFM and from 0.03 to 0.16 Nm/kg FFM.

### CONCLUSION:

Persistent pain after breast cancer treatment does not appear to influence the test-retest reliability of active shoulder range of motion and isokinetic shoulder strength. The substantial to almost perfect relative reliability values found in this study are in agreement with previous findings and support the use of these metrics for evaluating the effect of exercise interventions on shoulder function and in BCS.

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## EFFECTS OF WHOLE-BODY ELECTROMYOSTIMULATION(WB-EMS) VS. WHOLE-BODY VIBRATION(WBV) VS. CONVENTIONAL BACK-STRENGTHENING TRAINING ON CHRONIC NON-SPECIFIC LOWBACKPAIN: A 3-ARMED RANDOMIZED CONTROLLED TRIAL

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### INTRODUCTION:

With a lifetime prevalence of 74 to 85%, up to three quarters of the general population suffer from back pain at least once in life (Schmidt et al. 2007). Approximately 80% of the underlying pain is considered non-specific. Recent studies have shown that exercise (e.g., strength training) can reduce pain intensity and improve physical function of patients with chronic non-specific low back pain (CNLBP). Meta-analyses provided compelling evidence on pain reduction following conventional exercise (Searle et al. 2015). Patients with CNLBP frequently report time restrictions and kinesiophobia as primary reasons for not being physically active. As a consequence, time-efficient and effective training programs are needed. Thus, the aim of this randomized controlled multicenter study was to compare the effects of WB-EMS and WBV with conventional back-strengthening training (CBT) on mean back pain intensity (MPI) and strength indices in patients with CNLBP.

### METHODS:

Two hundred forty patients between 40-70 years of age (62% female) were randomly assigned to the intervention arms (WB-EMS: n=80; MPI: 3.08 (1.89) VAS vs. WBV: n=80; MPI: 2.94 (1.51) VAS vs. CBT: n=80; MPI: 2.94 (1.51) VAS). All training intervention programs were performed for 12 weeks at commonly applied & recommended training volumes (WB-EMS: 1x20 min/week vs. WBV: 2x15min/week vs. CBT: 1 x 45 min/week). Before and after the intervention MPI (VAS-Scale 0-10) was recorded using a 4-week pain diary. Additionally, maximal isometric voluntary trunk strength was assessed on the BackCheck machine for trunk extension and flexion.

### RESULTS:

The MPI moderately & significantly decreased in all groups (WB-EMS: - 29.7% (SMD 0.50) vs. WBV: -30.3% (SMD 0.57) vs. CBT: - 30.5% (SMD 0.59);  $p < 0.001$ ). A similar picture was observed for maximal isometric strength parameters with an increase in all groups (extension: WB-EMS: 17.1% vs. WBV: 16.2% vs. CBT: 21.6%;  $p < 0.001$ ; flexion: WB-EMS: 13.3% vs. WBV: 13.9% vs. CBT: 13.9%;  $p < 0.001$ ). However, no significant interaction effects for MPI ( $p = 0.920$ ) and maximal isometric strength parameters (extension:  $p = 0.436$ ; flexion:  $p = 0.937$ ) favoring a certain training regime were observed.

### CONCLUSION:

In conclusion, all 3 training programs are comparably effective at notably different training volumes (WB-EMS: 200.9 (20.4) min vs. WBV: 321.5 (45.0) min vs. CBT: 470.63 (52.3) min) in reducing low back pain intensity and in increasing trunk strength. These findings indicate that WB-EMS as well as WBV are effective and time-efficient training approaches compared to conventional back strengthening training for patients with CNLBP.

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**OP-MH06 Exercise and cancer****EFFECTS OF RESISTANCE TRAINING ON MUSCULAR STRENGTH IN BREAST CANCER SURVIVORS: THE EFICAN RANDOMIZED CONTROLLED TRIAL**

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**INTRODUCTION:**

One of the main side effects of breast cancer treatment is the loss of muscular strength, that can reach up to 25% in the lower body (1). Muscular strength can be improved through resistance training or resistance combined with aerobic training. Although several exercise trials have attempted to enhance muscular strength in breast cancer patients, very few have consistently applied the training principles and standardized reporting, and this partly explains the large variability in results. Thus, the extent to which breast cancer survivors can improve upper- and lower-body muscular strength following supervised exercise remains unclear. The primary aim of the Ejercicio Físico y CÁncer de Mama (EFICAN) Study was to assess the effects of 12-week supervised resistance exercise combined with instructions to undertake aerobic exercise, compared with a controlled condition consisting in instructions to undertake aerobic exercise only, on muscular strength in breast cancer survivors.

**METHODS:**

The EFICAN Study, registered at <http://www.isrctn.com/ISRCTN14601208>, is a parallel group randomized controlled trial conducted between September and December, 2019, in which 60 women breast cancer survivors, who completed core treatments within the last 10 years, were randomly assigned to either exercise (i.e. 2 sessions/week of progressive resistance training for 12 weeks plus instructions to undertake >10,000 steps/d), or control (i.e. instructions to undertake 10,000 steps/d, only). A comprehensive description of the exercise intervention is published elsewhere (2). Outcomes were evaluated at baseline and at week 12. Primary outcome measure was peak isometric muscular strength, assessed through the mid-thigh pull test, right and left unilateral knee extension in closed kinetic chain, bilateral seated bench press, and bilateral seated row with an electromechanical dynamometer (Dynasystem Research, Symotech, Granada, Spain).

**RESULTS:**

The mean age was 52.3 (SD 9.0) years and the mean BMI 26.9 (SD 4.7) kg/m<sup>2</sup>. A total of 32 women were randomly assigned to exercise and 28 to control. Preliminary linear regression analyses revealed that, in comparison to control, the exercise group increased muscular strength by 256.0 (95% CI 90.1 to 421.9; P=0.003) N in the mid-thigh pull test, 113.9 (95% CI -21.1 to 248.9; P=0.098) N in right unilateral knee extension, 176.6 (95% CI 60.6 to 292.6; P=0.004) N in left unilateral knee extension, 34.2 (95% CI 13.4 to 55.1; P=0.002) N in bilateral bench press, and 39.5 (95% CI 20.8 to 58.2; P<0.001) N in bilateral seated row at week 12.

**CONCLUSION:**

Muscular strength increased substantially following 12 weeks of resistance training in breast cancer survivors who had completed their core treatments within the last 10 years. These results highlight the potential of exercise to maintain physical independence and improve mid- and long-term quality of life in this population.

**DOES EXERCISE INTENSITY MATTER FOR FATIGUE DURING (NEO-)ADJUVANT CANCER TREATMENT? THE PHYS-CAN RANDOMISED CONTROLLED TRIAL**

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**INTRODUCTION**

Exercise is safe and beneficial during and after cancer treatment. Cancer-related fatigue (CRF) is a common, debilitating condition that can be prevented or reduced by exercise (1). However, little is known about the role of exercise intensity in counteracting CRF. Many patients find it difficult to perform exercise during demanding treatments, and it is unclear if self-regulatory behaviour change support (BCS) can facilitate exercise (2, 3) and in turn influence health outcomes such as CRF. The aim of this study was to compare the effects of high vs. low-to-moderate intensity exercise with or without self-regulatory BCS on CRF in patients undergoing (neo-) adjuvant treatment.

**METHODS**

This was a multicentre, 2x2 factorial design randomised controlled trial (Clinical Trials NCT02473003) in Sweden. Patients recently diagnosed with breast, prostate or colorectal cancer undergoing (neo-)adjuvant treatment were randomised to high or low-to-moderate intensity exercise, with or without self-regulatory BCS such as goal-setting, planning and self-monitoring of exercise. The 6-month exercise intervention consisted of supervised resistance training and home-based endurance training. CRF was assessed by the Multidimensional Fatigue Inventory (MFI, subscales score range 4-20), and the Functional Assessment of Chronic Illness Therapy-Fatigue scale (FACIT-F, score range 0-52). Multiple linear regression for main factorial effects was performed according to intention-to-treat, with post-intervention CRF as primary endpoint.

**RESULTS:**

Overall, 577 patients (mean age 58.7 years) were randomised. Patients randomised to high vs. low-to-moderate intensity exercise had lower physical fatigue (MFI Physical Fatigue subscale; mean difference -1.05 [95% CI:-1.85,-0.25]), but the difference was not clinically important (i.e. not ≥2). We found no differences in other CRF dimensions and no effect of self-regulatory BCS. Thirty-two minor adverse events (muscle strains, joint pain and dizziness) occurred in 30 patients, and three additional patients needed to attend hospital due to more serious adverse events (one finger injury and two faintings).

**CONCLUSION**

To counteract CRF, patients undergoing (neo-)adjuvant treatment for breast, prostate or colorectal cancer can safely exercise at high or low-to-moderate intensity, according to their own preferences. Self-regulatory BCS does not provide extra benefit for CRF in supervised, well-controlled exercise interventions.

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### DOSE-RESPONSE EFFECTS OF AEROBIC EXERCISE ON ADIPOSITY MARKERS IN POSTMENOPAUSAL WOMEN: POOLED ANALYSES FROM TWO RANDOMIZED CONTROLLED TRIAL.

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## INTRODUCTION:

Exercise may reduce the risk of breast cancer through attenuating adiposity, but the dose-response effects of exercise volume on adiposity markers are unknown in postmenopausal women. We aimed to compare the dose-response effects of prescribed aerobic exercise volume on adiposity outcomes.

## METHODS:

Data from the Alberta Physical Activity and Breast Cancer Prevention (ALPHA) and Breast Cancer and Exercise Trial in Alberta (BETA) were pooled for this analysis (N=720). These were 12-month randomized controlled trials, where participants were randomized to 225 minutes/week (mid-volume) of aerobic exercise versus usual inactive lifestyle (ALPHA), or 150 minutes/week (low-volume) versus 300 minutes/week (high-volume) (BETA). Fat mass and fat-free mass were measured using DXA and intra-abdominal and subcutaneous fat area were assessed with computed tomography at baseline and 12-months.

## RESULTS:

After 12 months of aerobic exercise, increasing exercise volumes from no exercise/control to 300 minutes/week resulted in statistically significant reductions in BMI, weight, fat mass, fat percentage, intra-abdominal and subcutaneous fat area ( $P < 0.001$ ). Compared with controls, weight loss was -1.47, -1.83, -2.21 kg in the low-, mid- and high-volume groups, respectively. Similarly, fat mass loss was -1.13, -1.98 and -2.09 kg in the low-, mid- and high-volume groups, respectively, compared to controls. Fat mass decreases were greater in the mid- and high-volume groups compared to the low-volume group, with no differences between the mid- and high-volume groups. Lastly, intra-abdominal fat area loss was -7.44, -15.56 and -8.76 cm<sup>2</sup> in the low-, mid- and high-volume groups, respectively, compared to controls. No evidence for a dose-response effect on fat-free mass was noted. Mean reductions in body weight noted in the present study may lead to an estimated 4.4%, 3.7% and 2.9% breast cancer risk reduction for the high, mid- and low-volume exercise prescriptions.

## CONCLUSION:

A dose-response effect of exercise volume on adiposity markers was noted, however, the differences in adiposity markers were smaller when comparing 225 minutes/week to 300 minutes/week of exercise. Postmenopausal women are encouraged to achieve a minimum of 150 minutes/week of exercise to reduce adiposity. However, greater volumes of exercise (225-300 minutes/week) are also needed to have greater reductions. Given the strong positive associations between obesity and postmenopausal breast cancer risk, this study provides evidence regarding the importance of exercise volume as part of the exercise prescription to reduce adiposity and, ultimately, postmenopausal breast cancer risk.

Sources of funding: Research Grant No. 017468 from the Canadian Breast Cancer Research Alliance (ALPHA Trial); Research Grant No. 24404 from the Alberta Cancer Foundation (BETA Trial)

Clinical trial registration number: clinicaltrials.gov identifier: NCT 00522262 (ALPHA Trial); NCT1435005 (BETA Trial).

### ANALYSIS OF THE BILATERAL LEG-PRESS LOAD-VELOCITY RELATIONSHIP IN BREAST CANCER SURVIVORS: THE EFICAN STUDY

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## INTRODUCTION:

Breast cancer is the cancer type with the highest incidence in women worldwide, with almost 2.1 million new patients diagnosed every year [1]. A negative side effect of the treatment is the loss of approximately 25% of the lower body muscle mass compared to healthy subjects [2]. Resistance training is an effective method to increase muscular strength levels in breast cancer survivors [3]. In addition, relative load is a key variable to prescribe an effective resistance training program. Interestingly, a close relationship has been found between movement velocity and the relative load (%1RM) that allows to accurately quantify it [4]. Due to leg-press exercise safety features and its great potential to be used in breast cancer patients, the aims of this study were to analyze the load-velocity relationship in this exercise in women breast cancer survivors and to examine what type of adjustment allows to predict with greater precision the velocities associated with each %1RM and the estimated 1RM.

## METHODS:

Twenty-two breast cancer survivor's women (age:  $50.2 \pm 10.8$  years, weight:  $69.6 \pm 15.2$  kg, height:  $160.51 \pm 5.25$  cm), as part of the EFICAN project [5], performed an incremental load test until 1RM in the leg-press exercise. The mean propulsive velocity (MPV) and the peak velocity (PV), measured using a linear velocity transducer (T-Force System), were analyzed by lineal (LA) and polynomial (PA) regression models. Movement velocity data is provided from 30-100% 1RM.

## RESULTS:

A very close relationship between MPV and relative load (%1RM) was observed ( $R^2 = 0.924$ ;  $p < 0.0001$ ;  $SEE = 0.08 \text{ m}\cdot\text{s}^{-1}$  by LA and  $R^2 = 0.952$ ;  $p < 0.0001$ ;  $SEE = 0.063 \text{ m}\cdot\text{s}^{-1}$  by PA). Similarly, a high correlation between %1RM and PV was observed ( $R^2 = 0.928$ ;  $p < 0.0001$ ;  $SEE =$

0.119 m.s<sup>-1</sup> by LA and R<sup>2</sup> = 0.941; p < 0.0001; SEE = 0.108 m.s<sup>-1</sup> by PA). The MPV at 1RM was of 0.23 ± 0.03 m.s<sup>-1</sup> and 0.28 ± 0.04 m.s<sup>-1</sup> by LA and PA, respectively. Instead, PV attained with the 1RM was 0.57 ± 0.10 m.s<sup>-1</sup> and 0.64 ± 0.09 m.s<sup>-1</sup> by LA and PA, respectively.

**CONCLUSION:**

LA and PA allow to predict the velocities associated with each %1RM and the estimated 1RM with a great precision in leg-press exercise in breast cancer survivor's women. However, PA showed better accuracy. MPV was considered the most recommended velocity variable to prescribe the relative load during resistance training. Differences in MPV could exist at the same sub-maximal load compared breast cancer survivors with others populations in the leg press exercise.

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**IS IT SAFE TO EXERCISE DURING ONCOLOGICAL TREATMENT? A STUDY OF ADVERSE EVENTS DURING EXERCISE - DATA FROM THE PHYS-CAN STUDY**

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**INTRODUCTION:**

Few studies have systematically evaluated the risk of negative effects (i.e. adverse events, AEs) for patients exercising during neo/adjuvant oncological treatment. Therefore, we aimed to describe the incidence, type of exercise-related AEs and related factors during exercise for persons undergoing oncological treatment. A second aim was to describe and compare the incidence of lymphedema, peripherally inserted intravenous catheter (PICC) related complications and new medical conditions occurring after inclusion in persons exercising on different exercise intensities.

**METHODS:**

This was a descriptive and comparative study based on data from the Phys-Can (Physical training and Cancer) study comprising of an observational study (n=90) and a randomized exercise trial (n=577). Participants in the exercise trial were randomized to high-intensity exercise (HI, n=288) or low-moderate (LMI, n=289) exercise. Patients with breast, prostate or colorectal cancer scheduled to start curative oncological treatment were included. Data regarding AEs occurring in the exercise trial was reported by exercise professionals (coaches), by participants or collected from medical records. Incidence of lymphedema and PICC complications was gathered from medical records for all participants in the intervention and participants with breast and colorectal cancer in the observational study (care as usual). New medical conditions were gathered from medical records for all participants in the intervention.

**RESULTS:**

20% of participants in the exercise trial (26,2% in HI and 15% in LMI) had a coach reported AE, of these, 97,2% were minor that did not prevent exercise. 22,1% had self-reported AEs (29,3% in HI and 15,0% in LMI). Participants in HI were more likely to have an AE than LMI when measured with both coach reported AEs OR:2,029 [CI 1,300-3,167], p =0,002, and participant reported AEs OR:3,464 [2,171-5,526], p =0,000. The incidence of lymphedema was low in both HI (8,6%), LMI (5,6%) and care as usual (4,0%). Rates of PICC complications were 17,4% in HI, 14,9% in LMI and 23,3% in care as usual group. There was no statistically significant difference between HI, LMI or care as usual regarding the incidence of lymphedema (p=.36), or PICC complications (p=.33). There was no statistically significant difference between participants in the HI and LMI regarding new medical conditions from medical records (p=.26).

**CONCLUSION:**

Exercise related AEs in persons undergoing oncological treatment are mostly minor and the incidence is similar to healthy populations. A slightly higher risk of minor exercise-related AEs in HI comparison to exercising on an LMI was reported. There is no evidence for an increased risk of developing lymphedema or PICC complications when exercising on a high intensity in comparison to the low-moderate intensity or care as usual. Additionally, exercise intensity is not associated with a higher incidence of new medical conditions.

**PRECISION EXERCISE IN CHILDREN AND ADOLESCENTS WITH HEMATOLOGICAL MALIGNANCIES AND/OR UNDERGOING HEMATOLOGICAL STEM CELLS TRANSPLANT**

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**INTRODUCTION:**

Children and adolescents with haematological malignancies (PedHM) are characterized by a severe loss of exercise ability along cancer treatment (including haematological stem cell transplant), lasting all over their lives once healed and impacting their social inclusion perspectives. Investigate the effect of a precision exercise program on the crosstalk between systems of the body in PedHM is the new frontier of clinical exercise physiology. This study aimed at the evaluation of the effects of 11 weeks, 3 times/weekly, combined training (cardiorespiratory, resistance, balance and flexibility), on the exercise intolerance in PedHM.

**METHODS:**

Three-hundred seven PedHM were recruited (43% F; 14% dropouts; 7 deceased) at Maria Letizia Verga Center (Monza, Italy). High and medium frequency adherences (HAd and MAd) were considered when a participant joined > 65% or between 30% and <64% of training sessions, respectively. The "up and down stairs" (TUDS), the "6 min walking" (6MWT), the "5 Repetition Maximum strength" leg extension and arm lateral rise (5RM-LE and 5RM-ALR), as well as the flexibility (stand and reach) and balance (stabilometry) tests, were evaluated before and after training. The quality of life (QoL) by a validated questionnaire and the satisfaction of the intervention by a visual analogue scale were measured too.

**RESULTS:**

The TUDS, the 5RM-LE and 5RM-ALR, and the flexibility showed an increase in HAd and MAd groups (P<0,05), while the 6MWT and balance tests were improved only in HAd group (P<0,0001). In HAd group an amelioration of QoL was noticed, mainly due to the increased exercise tolerance that impacted their social behaviour (P<0,05). The satisfaction of the intervention that the Sport Therapy program has provided has been extremely high (9,4/10).

**CONCLUSION:**

An extensive number of PedHM have been included in this study, with varying grades of frailty and our results entirely support the idea that moderate to high-intensity exercise is not detrimental for PedHM. The precision exercise program impacted both aerobic, strength, balance and flexibility characteristics especially in PedHM attending the training sessions with HAd. The QoL gave reason of exercise as key of the inclusion process in the original community of each child/adolescent. In Precision based exercise training is a challenge to fight for: it is possible when multidisciplinary collaboration is available between paediatricians and sports medicine experts. A precision exercise program is a vast opportunity to improve the performance of PedHM and should be considered as part of their care. We contend that PedHM, if supported by tailored training programs from the diagnosis of cancer, can potentially become healthy adults and perform as high-level athletes.

### **MULTIDIMENSIONAL PREDICTIVE MODEL OF CRF IN BREAST CANCER PATIENTS TO ESTIMATE THE INDIVIDUAL MECHANISMS**

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#### **INTRODUCTION:**

Cancer-related fatigue (CRF) is defined as a distressing persistent subjective sense of physical, emotional, and/or cognitive tiredness or exhaustion related to cancer or cancer treatment that is not proportional to recent activity that interferes with usual functioning [1]. CRF is the most reported side-effect of cancer with prevalence between 59 and 100%, according to cancer and treatment type [2]. This sense of exhaustion impairs the quality of life. The supposed mechanisms of CRF are numerous and include physical, psychological and behavioral dimensions. Moreover, the causes can differ between individuals. The purpose of this study was to test a multidimensional model of CRF in breast cancer patients and to better apprehend the individual mechanisms.

#### **METHODS:**

Thirty-three women with breast cancer ( $57.7 \pm 10.2$  years; Stage I to IV) were recruited while treatments (chemotherapy, radiotherapy and/or hormone therapy) were on progress or completed for less than 2 years. Participants completed self-assessment questionnaires about quality of life, CRF, sleep disturbances and emotional symptoms (EORTC QLQ-C30, FA12, PSQI and HADS, respectively). They also performed a 5-min handgrip fatiguing test composed of 60 Maximal Voluntary Contractions (MVC). Each MVC lasted 4 s and followed by a 1 s rest. Force-time relationship asymptote (FA) was used as a neuromuscular fatigability indicator and curvature constant ( $\tau$ ) as the rate of force decrease [3]. Stepwise multiple linear regression analyses were performed to investigate the influence of predictor variables (i.e., age,  $F_{peak}$ , FA,  $\tau$ , PSQI and HADS total score) on CRF (represented by the FA12 total score). The relative predictive power ( $\beta^*$ ) of each variable was calculated. Then the parts of predicted CRF related to the variables included in the model were computed for each participant.

#### **RESULTS:**

The multiple linear regression analysis evidenced that CRF was best explained by a model including HADS total score, FA and PSQI total score ( $r^2 = 0.55$ ;  $p < 0.001$ ) and  $\beta^*$  were 0.32; 0.42 and 0.39, respectively.

#### **CONCLUSION:**

These results reveal that sleep disturbances, emotional symptoms and neuromuscular fatigability were the most important CRF predictors in breast cancer. These variables were previously related individually to CRF, but this study is, to our knowledge, the first to combine emotional, behavioral and neuromuscular parameters in a CRF prediction. It enables to understand predominant CRF mechanism at the individual level. These results are particularly relevant to field applications as supportive care tailoring to individual CRF causes when focusing on CRF improvement.

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### **A COMPARISON OF SHOULDER JOINT RANGE OF MOTION AND SHOULDER STRENGTH IN WOMEN SUFFERING FROM PERSISTENT PAIN AFTER BREAST CANCER TREATMENT AND CONTROL PARTICIPANTS**

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#### **INTRODUCTION:**

Approximately 25–60% of all women who undergo treatment for breast cancer will experience persistent pain in the surgical area (1). This late effect is considered the source of considerable physical disability, especially in the shoulder joint (2)(3). The aim of this study was therefore to assess shoulder joint range of motion and shoulder strength levels in women with persistent pain after breast cancer treatment and asymptomatic control participants.

#### **METHODS:**

Twenty-one women with persistent pain after breast cancer treatment and 21 asymptomatic control participants matched for age and body mass index participated in a familiarization session and an experimental session. Active range of motion of the shoulder joint was assessed using a goniometer for supine shoulder flexion, supine horizontal shoulder adduction/abduction, seated shoulder abduction, and supine internal/external shoulder rotation with 90° abduction of the upper arm. Torque at 60°/sec in the before mentioned movements was assessed using an isokinetic dynamometer. All participants performed a general warm-up of the prime movers in the upper body. In the isokinetic tests, a set of 10 repetitions with progressive effort was carried out in the dynamometer. After two minutes of rest, the participants performed a set of 5 repetitions with maximal effort. Torque was recorded at a fixed joint angle for the last four repetitions, and mean value was defined as peak torque. Peak torque was normalized to fat free mass (FFM), estimated through segmental bioelectrical impedance measurement.

#### **RESULTS:**

The results of the present study showed that the women with persistent pain had significantly lower range of motion in shoulder flexion (patient:  $158.6 \pm 16.5^\circ$ , control:  $171.0 \pm 7.3^\circ$ ,  $p \leq 0.05$ ), horizontal abduction (patient:  $97.9 \pm 16.2^\circ$ , control:  $113.1 \pm 7.1^\circ$ ,  $p \leq 0.05$ ), and external rotation (patient:  $72.6 \pm 15.5^\circ$ , control:  $90.1 \pm 13.0^\circ$ ,  $p \leq 0.05$ ) compared with the control participants. Similarly the women with persistent pain displayed significantly lower strength levels in horizontal shoulder abduction (patient:  $0.44 \pm 0.13$  Nm/kg control:  $0.54 \pm 0.10$  Nm/kg,  $p \leq 0.05$ ) and shoulder adduction (patient:  $0.41 \pm 0.10$  Nm/kg, control:  $0.54 \pm 0.09$  Nm/kg,  $p \leq 0.05$ ).

CONCLUSION:

In conclusion, women with persistent pain following breast cancer treatment exhibit decreased range of motion and strength levels most likely caused by the long-term pain symptoms experienced in this group. This renders these women a relevant group for intervention consisting of individualized strength training.

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(2) Shanley D et al., Acta Oncologica, 2012.

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**MAINTENANCE OF BODY COMPOSITION AND PHYSICAL FUNCTION AFTER INTENTIONAL WEIGHT LOSS FOR PROSTATE CANCER PATIENTS ON ANDROGEN DEPRIVATION THERAPY**

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EDITH COWAN UNIVERSITY

INTRODUCTION:

Androgen deprivation therapy (ADT) is a mainstay treatment for prostate cancer that patients may receive for several years. Adverse body composition changes are a common side effect of ADT, with increased fat mass and loss of lean mass associated with poor prostate cancer prognosis and quality of life. Using exercise and nutrition interventions, fat mass may be reduced and lean mass preserved while on ADT, however, it is unclear if these changes can be maintained following supervised interventions and continuing on treatment. Aim: to examine the maintenance of body composition and physical function over a 12-week self-managed exercise programme following a 12-week clinic-based exercise and nutrition weight loss intervention in prostate cancer patients receiving ADT.

METHODS:

Eleven men on long-term ADT (> 6 months) aged 63 to 82 years completed a 12-week clinic-based weight loss intervention comprising a 2000 – 4000 kJ deficit diet and 300 minutes of combined moderate- to high-intensity aerobic and resistance exercise each week. The weight loss intervention was followed by a 12-week programme under self-management where patients were recommended to complete 150 minutes of combined aerobic and resistance training each week. Whole body and regional fat mass (FM) and lean mass (LM) were assessed by dual-energy x-ray absorptiometry, upper- and lower-body muscle strength by one-repetition maximum, and aerobic capacity by the 400m walk test. Analysis was undertaken using paired t-tests or the Wilcoxon signed-ranked test, as appropriate.

RESULTS:

Following the weight loss intervention, patients experienced a significant reduction in weight ( $-2.8 \pm 3.2$  kg,  $p = 0.016$ ), due to a decrease in FM ( $-2.8 \pm 2.6$  kg,  $p = 0.005$ ) with LM preserved ( $-0.05 \pm 1.6$  kg,  $p = 0.922$ ). Muscle strength also significantly increased for the leg press ( $24.7 \pm 24.5\%$ ,  $p = 0.005$ ), chest press ( $19.8 \pm 16.5\%$ ,  $p = 0.006$ ), and seated row ( $4.6 \pm 6.6\%$ ,  $p = 0.039$ ). No change was observed for the 400m walk test ( $0.7 \pm 6.6\%$ ,  $p = 0.700$ ). During the self-management period, there was no significant change in FM ( $0.2 \pm 1.4$  kg,  $p = 0.619$ ) or LM ( $-0.8 \pm 1.6$  kg,  $p = 0.146$ ), leg press ( $4.1 \pm 5.6\%$ ,  $p = 0.086$ ), chest press ( $-0.2 \pm 13.8\%$ ,  $p = 0.745$ ), or seated row ( $1.0 \pm 8.4\%$ ,  $p = 0.744$ ) muscle strength, or for the 400m walk ( $-0.5 \pm 6.5\%$ ,  $p = 0.859$ ).

CONCLUSION:

Prostate cancer patients remaining on ADT following a clinic-based exercise and nutrition weight loss programme are able to maintain the beneficial effects on body composition and muscle strength with the completion of a self-managed exercise programme.

OP-MH07 Exercise, brain and cognitive function

**SEDENTARY BEHAVIOR AND EXECUTIVE FUNCTION IN CHILDREN WITH OVERWEIGHT/OBESITY: THE ACTIVEBRAINS PROJECT**

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INTRODUCTION:

Previous studies have showed that a sedentary behavior has been associated with physical and mental health problems in children; however, there are few studies that have examined the association of different sedentary behaviors and executive function in children. In addition, previous literature has shown that children with overweight/obesity have worse executive function than those with normal weight. The aim was to analyze the association between different sedentary behaviors and executive function in children with overweight/obesity.

METHODS:

Ninety nine children (39 girls) from 8 to 11 years old with overweight/obesity from the ActiveBrains project participated in this study. Sedentary behaviors were determined with the questionnaire YAP (Youth activity profile), obtaining information on television (TV) time, videogame time and total sedentary time. Four domains of the executive function were included. Cognitive flexibility was assessed by paper-pencil test "Design Fluency Test" and "Trail Making Test", and a composite Z-score was computed. The inhibition was evaluated with the "Stroop Test", while planning was evaluated using the "Zoo Map Test". Working memory was evaluated using a modified version of the computerized task "Delayed Non-Match-to-Sample" (DNMS) for children for children with high and low demanding task conditions. Two linear regression models were performed for each sedentary behavior variable, model 1 adjusted for sex, biological age, parental education and body mass index; and model 2 was further adjusted for fitness.

RESULTS:

A higher TV time was associated with a lower planning capacity in both models (model 1:  $\beta = -0.246$ ,  $p = 0.014$ ; model 2:  $\beta = -0.245$ ,  $p = 0.015$ ). No associations were found between the time expended in videogames and the total sedentary time, and the planning capacity ( $p > 0.05$ ).

A higher TV time was also associated with a worse working memory in high (model 1:  $\beta = -0.298$ ,  $p = 0.002$ ; model 2:  $\beta = -0.298$ ,  $p = 0.002$ ) and low (model 1:  $\beta = -0.351$ ,  $p = 0.000$ ; model 2:  $\beta = -0.351$ ,  $p = 0.000$ ) demanding task conditions. No associations were found between the time expended in videogames and the total sedentary time, and the working memory ( $p > 0.05$ ).

No associations were observed for all sedentary behaviors indicators with inhibition and cognitive flexibility ( $p > 0.05$ ).

CONCLUSION:

Time watching TV could have a negative influence in the planning capacity and working memory of children with overweight/obesity. The time expended in videogames as well as total sedentary time may not have such influence in executive function. In this specific approach about type of sedentariness, TV time shows a consistent association with worse executive function, future research need to specifically to study types of sedentary behaviors and its influence of cognitive outcomes.

### **EFFECT OF EXERCISE-INDUCED APELIN SECRETION ON COGNITIVE FUNCTION IN PATIENTS WITH MILD COGNITIVE IMPAIRMENT**

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#### **INTRODUCTION:**

Several studies have examined the role of the protein apelin in both muscle/organ function and disease since its identification in 1998 [1]. Also, during muscle contraction, a protein is secreted from the muscle, the protein is known as a myokine, reports indicate that myokines improve cognitive function [2]. The aim of this study was to determine the effect of resistance exercise on serum apelin levels and on cognitive function in patients with mild cognitive impairment.

#### **METHODS:**

Blood samples were collected before and after 12 weeks of high- or low-speed resistance exercise training. We measured cognitive function (K-MMSE & MoCA-K), physical performance (SPPB), isokinetic contraction (60° & 180° extension and flexion), and serum apelin levels in 29 subjects who underwent either a high- or low-speed elastic band exercise training.

#### **RESULTS:**

We observed a positive correlation between eccentric contractions and cognitive function ( $p < .05$ ). In addition, both physical performance and cognitive function were improved in the exercise group ( $p < .05$ ). We also observed increased serum apelin levels after both high- and low-speed resistance exercise, it was positively correlated with increased cognitive function ( $p < .05$ ). Therefore, serum apelin levels correlate with eccentric muscular contractions and increased cognitive function.

#### **CONCLUSION:**

The serum apelin levels have a direct correlation with eccentric muscular contraction and cognitive function. In addition, the 12 weeks of resistance exercise can attenuate the cognitive function and increase the serum apelin level. Resistance exercise thus increases cognitive function by promoting the release of exerkines such as apelin.

### **PHYSICAL ACTIVITY, SEDENTARY BEHAVIOR AND COGNITION IN ELDERLIES LIVING IN A RETIREMENT COMMUNITY: THE IMPACT OF FRAILTY STATUS**

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#### **INTRODUCTION:**

Frailty is characterized by reduced physiological reserve and resilience that places elderlies in elevated risk for detrimental declines in health and function [1] and may negatively affect lifestyle behaviors, and cognition. This study examined differences in physical activity (PA), sedentary behavior (SB) and cognition in elderlies living in a retirement community (RC) as a function of frailty status.

#### **METHODS:**

A hundred elderlies were recruited from a RC. Frailty was verified using the Short Physical Performance Battery (SPPB). Total SPPB score was used to categorize participants into different groups based on the cut-off of 9 points previously stated in the literature [2]. Fifty-eight participants had a score  $\leq 9$  and were classified as frail and 41 had a score  $> 9$  and were classified as non-frail. PA and SB were assessed using self-report questionnaires. Cognition was assessed using: the Symbol Digit Modalities Test (SDMT), the California Verbal Learning Test-II (CVLT-II), the Brief Visuospatial Memory Test-Revised (BVM-T-R), and the Category Fluency Test (CFT). These tests measure information processing speed, verbal learning and memory, visuospatial learning and memory, and verbal or semantic fluency, respectively. Data were analyzed using independent t test and ANCOVA. Statistical significance was set at  $p < .05$ .

#### **RESULTS:**

The average age of the participants was 84.7 (6.3) years with the frail group being significantly older than the non-frail group ( $P < 0.01$ ). A marginal difference in PA scores (non-frail, 66.5 (43.1) x frail, 49.6 (41.3);  $P = .05$ ) and SB time in hours per day (non-frail, 10.6 (3.3) x frail, 9.3 (3.3);  $P = .06$ ) was observed between groups. Participants classified as non-frail performed significantly better ( $P < .05$ ) than their counterparts in the frail group on the SDMT, CVLT-II and BVM-T. A marginal difference ( $P = .053$ ) between groups was observed for CFT. Analysis of covariance revealed a statistically significant difference between groups for the SDMT (non-frail, 40.0 (1.5) x frail, 34.2 (1.3);  $F(1,97)=7.77$ ;  $P = .006$ ). Performance in the CVLT was only marginally different between groups ( $P = .061$ ) and no difference was observed for BVM-T ( $P = .14$ ).

#### **CONCLUSION:**

The findings suggest that non-frail and frail elderlies do not present with significant differences in PA and SB. Initial analysis demonstrated that frail elderlies performed worse in all cognitive measures employed but only processing speed remained significantly different between groups after controlling for age. Strategies and interventions focusing on improving the health of elderlies living in RC are of great importance.

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### **DEPENDENCY RATIO AND PHYSICAL ACTIVITY LEVEL IN RESIDENTIAL FACILITIES FOR SENIOR ADULTS**

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#### **Abstract**

Objective: To determine the dependency ratio and global physical activity of senior adults living in residential facilities.



**Materials and Methods:** A specific questionnaire on physical activity was conducted among 424 residents between the ages of 60 and 96, in 18 residential care facilities in Seville (Spain), being the candidates selected by stratified random sampling. The dependency ratio and physical activity levels were determined by PSDQ (Physical Self-description Questionnaire) for the elderly in residential facilities.

**Results:** The total of the respondents' ages ranged between: 60 to 69 (6.8%), 70 to 79 (24.3%), 80 to 89 (48.8%), and  $\geq 90$  (20%). 55.7% of the respondents are dependent for bathing and toileting and 68.4% depend on mobility aids such as canes (19.3%), walkers (43.4%) and wheelchairs (37.2%). However, only 7.5% of residents are feeding dependent, with this activity being the one that requires the least movement. Physical activity is scarce; the study shows that the higher the age of the resident is, the less activity they undertake. Walking is the most practiced physical activity by senior adults, 66.67%; although each walking session is less than 30 minutes in 65.8% of the cases and 29.2% of respondents walk less than 10 minutes a day. Any other physical activities are highly unusual. According to current regulation, every residential facility must have a physical therapy room or gym. In many interviews, the respondents from the residential facilities confirm they receive their physiotherapy sessions in the gym or physical therapy rooms. As a result of this guided therapy session, a high 67.9% of residents attend at least once a week. All of the above mentioned reflects the low practice levels of physical activity in residential facilities, leading to senior adults' continued dependency, and therefore physical led-activity becomes a social necessity.

**Conclusions:** the survey indicates the prevalence of dependency levels and lack of physical activity expert-led programmes. The total indicators on regular practice of physical activities are nil or scarce.

### **EXERCISE AS MEDICINE: REDUCING THE SEVERITY OF AUTISM SPECTRUM DISORDER SYMPTOMS IN CHILDREN**

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#### **INTRODUCTION:**

Autism spectrum disorder (ASD) is a developmental disorder defined by the presence of persistent deficits in social communication, interaction and repetitive patterns of behavior, interests, or activities with severity classified as mild, moderate and severe (American Psychiatric Association, 2013). Exercise has shown to be beneficial for children with ASD; improving social and communication skills, increasing confidence, and decreasing stereotypical behaviours (Sorensen and Zarrett 2014). However, there is limited data assessing whether exercise can affect the severity of ASD symptoms.

#### **METHODS:**

Fifty-seven children (mean age 7.7 years) with ASD underwent an 8-week group-based exercise intervention program consisting of one hour, three days a week, of moderate to vigorous intensity activities including running, jumping, throwing, catching, and fun games. Teachers of the children completed the Gilliam Autism Rating Scale 2nd Edition pre- and post-intervention to categorise the children's autism severity as mild, moderate, or severe. Changes in teacher-report scores were compared from pre- to post-intervention and presented as percentage change over the course of 8-weeks. A chi-squared test was conducted to examine if changes in ASD severity levels differed between the mild, moderate and severe groups following the exercise intervention.

#### **RESULTS:**

After the implementation of the 8-week exercise intervention program, the severity of symptoms changed. 37% (n=19) of children, who were scored as having severe ASD in pre-test were reported to have moderate symptoms at post-test, with an overall improvement of symptoms by 77%. Similarly, 19% of children (n=16), who were reported to have moderate ASD at pre-test were reported to have mild symptoms at post-test, with an overall improvement of symptoms by 65%. Children with mild ASD had their symptoms improved by 44%. The chi-squared test demonstrated that the three ASD severity groups responded significantly differently to the changes in severity levels ( $p < 0.02$ ) following the exercise intervention.

#### **CONCLUSION:**

This study's findings suggest that an eight-week supervised exercise intervention that includes developmentally appropriate exercises and active games may be effective in reducing the severity of symptoms in children with ASD. Exercise should be further studied and utilized for children with ASD as it shows great promise in reducing the severity of ASD symptoms. Additional research is needed to examine not only the dose response, but also the quality of the movement experience for children with ASD.

### **MEDICAL COSTS OF PLAYER INJURIES IN U.S. RUGBY-7'S REGIONAL TOURNAMENTS: A FIVE YEAR ANALYSIS**

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*1:RRIPG-HSS 2:UMKC SOM 3:AUT/SPRINZ 4:USAR EMPIRE/NEW ENGLAND 5:NRODA 6:UM-MOI 7:NYU 8:TMC 9:HSS 8:TMC 9:HSS 10:NBA 11:USA BASKETBALL*

#### **INTRODUCTION:**

Rugby-7s is an Olympic collision sport, played internationally with a high injury incidence (Fuller et al, 2017). USA Rugby (USAR) regional Geographic Rugby Football Unions (GUs) conduct qualifying Rugby-7s multi-tournament series, across the US, and showcase regional winners, possible Olympic candidates, at the USAR National Club-7s Championships (Lopez et al, 2016). Rugby-7s GU tournaments injury burden have yet to be quantified, therefore, injury cost data, would aid injury prevention and event preparedness. Our study aims to quantify injured player medical costs sustained in a USAR-sanctioned Rugby-7s series.

#### **METHODS:**

A prospective epidemiology study using the Rugby Injury Survey & Evaluation (RISE) Report methodology was employed to capture injury data (Lopez et al, 2012), following the rugby consensus statement (Fuller et al., 2007). Injury data over 2010-2015 in the USAR Northeast GUs qualifying series, evaluated provisional diagnosis, injury severity, treatment, and follow-up, using current coding programs (ICD-10-CM) including on-field and follow-up billing (CPT/HCPCS) with institutional charges in US dollars (US\$). Injury severity=days absent, was reported as a "time-loss" injury or required medical attention

#### **RESULTS:**

The total estimated medical costs of injuries (n=1084) over 5-years in a regional rugby-7s series were US\$208,546.53 (Men, n=834, \$163,888.21; women, n=249, \$44,658.32). The average multi-tournament series medical costs were \$27,224, with the highest annual cost in 2012 (\$45,670.57), and the lowest in 2010 (\$13,542.40). Average medical costs in an individual tournament in a series varied (lowest=\$2,646.90, to highest=\$7,349.76). The highest study period costs were fractures (\$29,622.06) followed by ankle sprains (\$16,053.51) then concussions (\$4,331.63).

#### **CONCLUSION:**

Injury costs to men were higher than women, meanwhile, tournaments costs varied, by year and individual event. Injuries with the highest costs were also likely to have a longer reported absent period absent, and used more services (i.e.; imaging, surgery, therapy). The average on-field costs, disregarding surgical follow-ups, had a steady increase in annual costs per tournament over the study period. Future medical cost studies could provide a stronger analysis of the global impact of this emerging sport, and will provide institutions and event management the data for emergency preparedness and response.

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**PLAYING THE BRAIN - NEUROPHYSIOLOGICAL EVIDENCE FOR CORTICAL PROCESSING DURING TABLE TENNIS**

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## INTRODUCTION:

There is evidence that physical activity indexed by cardiovascular and muscular strength training is able to stimulate brain areas to slow down or even prevent cognitive decline (CD) in the elderly (Sprague et al., 2019). Motor coordination training in terms of table tennis (TT) combining motor and cognitive aspects might also be promising to improve cognitive functioning. But direct neurophysiological evidence whether and how TT affect cortical activity compared to rest or a cognitive task is lacking. Even if electroencephalography (EEG) gets mobile while playing racket games like TT, it is unknown whether brain activity will be disturbed by movement artifacts. Therefore, the aim of the present pilot study was to investigate feasibility of deriving changes in brain activity during TT play compared to a resting situation and a cognitive task.

## METHODS:

Ten healthy young non-TT-expert subjects (24.5±4.8 years, 68.3±20.5 kg, 170.2 ±11.6 cm) performed a standing baseline (BS) and three blocks of three minutes of a) two-back task (TB) and b) ongoing table-tennis play (TT) with consecutive EEG assessment. EEG data was preprocessed applying notch-filter, bandpass-filter, re-referencing and manual rejection of non-stereotype artifacts. Artifact-free data was analyzed in source-space applying independent component analysis (ICA). Based on clusters of functional brain components, power changes in theta and alpha activity were compared between BS, TB and TT.

## RESULTS:

ANOVA for repeated measures revealed significant decreases in alpha power for TT and TB compared to BS in right-motor, left-motor, right parietal and left-parietal clusters.

## CONCLUSION:

The findings reveal evidence for the feasibility of measuring brain activity during TT play indicated by decreased alpha activity in central and parietal brain areas. A decrease in alpha is associated with elevated sensorimotor processing and attentional demands (Neuper, 2006) and could imply a stimulation of the brain during TT play. Thus, TT might be able to act as a promising intervention in CD in a safe and attractive environment, as playing TT is widely spread even in elderly. Consequently, future studies need to assess cortical processing during TT in elderly subjects in a longitudinal study.

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**THE CONCEPT OF GIVING EXTRA POINTS DUE TO CLASSIFICATION (FACTOR SYSTEM) IN PARA-KARATE DOES NOT GIVE ADVANTAGE OR DISADVANTAGE TO THE ATHLETES**

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## INTRODUCTION:

In 2015 the World Karate Federation (WKF) became a recognized IF by the International Paralympic Committee (IPC). After being accepted as a member of the IPC by the bodys Governing Board, Karate will be able to submit a bid for inclusion in the 2024 Summer Paralympics.

In the sport of Para-karate, it is only possible for an athlete to compete only in Kata, not in kumite (sparring). Within Kata, there are three athlete categories available:

- Blind or Visually Impaired (VI)
- Intellectually Impaired (II)
- Wheelchair user (WU)

All three areas have separate divisions for Male and Female athletes

Prior to the competition, each athlete must present diagnosis documents and participate in a medical evaluation and classification. The athlete classification consists of a point-based factor system, instead of the evidence-based classification system which separates athletes into sports classes.

The IPC prefers the individual IF's to use sport classes in lieu of factor/point-based systems because the factor system should be problematic. As of this date, the karate point based factor system can award up to 3 extra points for each athlete's composite score, prior to competition, based on the evaluation and severity of the disabilities.

The aim of this study is to investigate if there is a relationship between the factor of impairment (extra points given to the athlete during the classification session) and the result (total score evaluation) at the top-level para karate competition.

**METHODS:**

We analysed results of the World Para-Karate Championships 2018 held in Madrid. That tournament, there were 124 athletes who competed in the 6 categories (listed above). Of those, 76 were males, 48 were females, and of those, 38 were Blind or Visually Impaired, 48 were Intellectually Impaired and 38 were Wheelchair Users.

Pearsons correlation coefficient was computed to assess the relationship between extra points and the total score given to the athlete.

**RESULTS:**

There is no relationship, neither positive nor negative, between extra points and ranking  $r(107)=0.08$ ,  $p=0.43$  and extra points and total score  $r(107)=0.01$ ,  $p=0.92$ . It means, that the final ranking does not depend on the factor system. It seems that the result depends on the athletes performance.

**CONCLUSION:**

It seems that the factor system is a good start point for Para-karate competition. The panel of classifiers worked with high professional standards, but a test of the classification's validity is needed. Results of the analysis suggest the factor system as a fair system of classification, with a few potential negatives:

- Potential of conceptual confusion (athletes, coaches and others could not clearly understand what is happening)
- There could be a potential lack of confidence in competition outcomes, which could lead to discouragement, and possibly affect growth levels in the sport,
- The system is open to cheating/abuse, offering a disadvantage to athletes with high support needs.

## OP-MH08 Health and fitness

### **VIGOROUS PHYSICAL ACTIVITY IS POSITIVELY ASSOCIATED WITH BONE MASS AT SITE SPECIFIC IN CHILDREN WITH OVERWEIGHT/OBESITY: THE MEDIATING ROLE OF CARDIORESPIRATORY FITNESS AND LEPTIN**

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**INTRODUCTION:**

Obesity and osteoporosis are escalating global epidemics that warrant increased attention by pediatricians and other health care professionals. Childhood obesity is not a direct cause of osteoporosis, but massive fat accumulation and its consequences (i.e. low-grade chronic inflammation) could impair the peak bone mass reached at the end of this stage.

Physical activity is effective for enhancing bone accretion during growth. Specifically, the frequency, the intensity and type of physical activity practiced may be potent regulators of bone remodeling. In terms of intensity, vigorous physical activity (VPA) seems to impact on bone mass due to higher mechanical stimuli. Moreover, VPA may improve cardiorespiratory fitness (CRF) which has been negatively associated with body composition parameters in this population. In this regard, the endocrine function and interplay between adipose, muscular and bone tissue might be affected.

Therefore, the aims of this study were to examine whether 1) the association between VPA and bone mass is site-specific; 2) CRF and leptin act as mediators in these associations in children with overweight/obesity.

**METHODS:**

Eighty-three children (9.9±1.2 years, 37.4% girls) with overweight/obesity from the ActiveBrains project were included in the analysis. VPA was assessed with the GT3X+ accelerometer placed on the right hip during 7 days (24h). The Euclidean Norm Minus One G (ENMO) with negative values rounded to 0 was derived from the raw accelerometer data over 5-s epochs. CRF was assessed using a gas analyzer while performing a maximal incremental treadmill test modified for poorly fit children. Plasma leptin concentration was analyzed using a sensitive ELISA kit. Bone mineral content (BMC) of the total body-less head (TBLH), lumbar spine (LS) and legs was assessed using dual-energy x-ray absorptiometry. As a first step, partial correlations controlling for sex, years from peak height velocity (PHV) and lean mass were run to check the relationships between the independent variable, mediators and outcomes. In addition, multiple mediation analyses adjusting for potential cofounders were fitted to test the objective 2.

**RESULTS:**

VPA was positively correlated with CRF ( $r=0.40$ ,  $P<0.001$ ) and legs BMC ( $r=0.25$ ,  $P=0.026$ ), whereas CRF was inversely correlated with leptin ( $r=-0.48$ ,  $P<0.001$ ). In mediation models, VPA was positively associated with legs BMC (total effect,  $c=0.053$ ,  $P=0.026$ ), whereas the association between VPA and TBLH BMC was borderline ( $c=0.041$ ,  $P=0.062$ ). No evidence of association was found between VPA and LS BMC ( $c=0.009$ ,  $P=0.823$ ); however, both CRF and leptin acted as mediators in this association ( $IE=0.022$  95%CI [0.001; 0.055]).

**CONCLUSION:**

The association between VPA and bone mass is more evident at skeletal sites with higher proportions of cortical bone (e.g. TBLH and legs), whereas CRF and leptin seem to act as mediators of this relationship at sites of predominantly trabecular bone (e.g., lumbar spine). These findings underlie the presence of a cross-talk between fat and bone in children with overweight/obesity.

### **CONCOMITANT ASSOCIATIONS BETWEEN MUSCULAR FITNESS SCORE AND BODY COMPOSITION IN SCHOOLCHILDREN AGED 8-12**

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**INTRODUCTION:**

Among the health-related physical fitness components, cardiorespiratory fitness (CRF) is the one that has been studied the most in youth, since it reflects the overall capacity of the cardiovascular and respiratory systems and the ability to carry out prolonged exercise. Specifically, muscular fitness (MF) is an important marker of health for monitoring child. The aim of this study was to describe and compare the body composition and physical activity level in schoolchildren aged 8 to 12 from the Region of Murcia (Spain), according to sex and MF status.

**METHODS:**

A descriptive and cross-sectional study was performed. A total of 248 schoolchildren (41% girls) aged 8-12 (9.7±1.2 years) from six primary schools from The Region of Murcia were enrolled in the study. To establish the MF score, the results of handgrip strength and standing long

jump tests were transformed into Z-scores by sex and age for the whole sample and then both transformed results were summed. Participants were divided into two groups: High MF group (second and third tertiles) and Low MF group (first tertile). Body mass index (BMI), waist circumference (WC) and skinfolds (triceps, biceps, subscapular and iliac crest) of the participants were taken following the recommendations of the International Society for the Advancement of Kinanthropometry (ISAK).

#### RESULTS:

Regarding body composition, statistically significant differences were found between low MF and high MF in both boys and girls ( $p < 0.001$ ); for BMI, WC, waist-to-height ratio and body fat percentage. At the same time, a negative relationship was found between MF and body mass index ( $p = -0.600$ ), waist circumference ( $p = -0.512$ ), waist-to-height ratio ( $p = -0.469$ ) and body fat percentage ( $p = -.625$ ). Finally, it was found a higher probability of having excess of weight (OR=12.27; CI95%=5.28–28.54), abdominal obesity (OR=10.99; CI95%=5.76–20.98) and high adiposity (OR=12.24; CI95%=4.20–35.67) in the low MF group.

#### CONCLUSION:

Considering all the limitations of our study, we showed that children participating in the current study with lower MF present inferior values than those with higher MF in body composition.

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### MODIFICATION OF THE LIPID PROFILE WITH AEROBIC AND STRENGTH EXERCISE

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#### INTRODUCTION:

The lipoproteins levels in the Lipid Profile (LP) in Blood (HDL, LDL, VLDL, Triglycerides, Cholesterol) are indicators of cardiovascular risk that are modified by various factors. The benefits of physical exercise for the prevention of cardiovascular risk factors are well known and widespread [1]. Several studies have analyzed the effects of aerobic and strength physical exercise separately [2,3]. However, modifications of the lipid profile after an aerobic and strength exercise session should continue to be investigated to obtain scientific evidence that allows prescribing exercise programs that help with the necessities of populations in specific ages. Therefore, the objective of this study was to determine the effect of an aerobic and strength training session on the PL of university students.

#### METHODS:

Physically active men ( $N = 42$ , age:  $21 \pm 2$  years) were evaluated with a maximum indirect oxygen consumption test (Leger test), maximum upper limb (pres plan) and lower limb (squat) was performed and a blood sample to measure the PL was taken before the session of exercise (8 hour fast) and post exercise. Two groups were established randomly, the first group "Strength" (GF):  $n = 22$  and the second group "Resistance" (GR)  $n = 20$ . A protocol was made for the GF of 6 exercises at intensity of 75% of the RM and volume of 4 series, of 12 repetitions. The GR run in band for 45 minutes at an intensity of 60 to 70% of the Maximum Aerobic Speed. Using the T-student test for paired samples, the pre and post PL values are compared, and the Pearson correlation test to find the relationships between the components of the PL and the characterization variables. The significance was set at  $P < 0.05$ , R. Studio 1.1.456 software was used.

#### RESULTS:

After the exercise session, the GR presented a significant decrease in LDL ( $p = 0.01$ ) and a significant increase in triglyceride concentrations ( $p = 0.0009$ ) and VLDL ( $p = 0.009$ ). GF significantly decreased LDL ( $p = 1.06e-06$ ), while triglycerides and VLDL increased ( $p = 6.6e-07$ ). No specific correlations are found between the characterization variables and the components of the PL in both groups.

#### CONCLUSION:

The PL varied in both GR and GF groups, triglyceride concentrations increased 26.3% and 40.7%, and in VLDL increased 26.2% and 40.9% respectively, while LDL decreased 3.2 % in GR and 9.8% in GF. It is found that an aerobic and strength exercise session modifies the PL. The strength session shows a change of 14.8% in VLDL, 14.4% in triglycerides and 6.6% in LDL, more than the aerobic exercise session. No correlations were found between the components of the PL and the characterization variables in the groups studied.

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### IMPACT OF PHYSICAL EXERCISE ON TRANSAMINASEMIA IN PATIENTS WITH NON-ALCOHOLIC ESTEATOHEPATITIS IN THE "HOSPITAL EUGENIO ESPEJO", ECUADOR

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#### INTRODUCTION:

Non-alcoholic steatohepatitis (NASH), is a variety of Non-alcoholic fatty liver disease with a substantial risk of progression to advanced fibrosis and mortality from liver failure (1). Since it is asymptomatic, the NASH Education Program estimates that the prevalence is around 12%, but is higher in people over 50 years of age, women, obese, diabetics and others, so it is considered the first cause of liver disease in the western world. (2).

Considering that there are no pharmacological therapies with sufficient scientific evidence, the treatment is diet and exercise, with a resolution rate up to 90% (3), same that can be controlled by transaminase levels (4).

#### METHODS:

Fourteen individuals were recruited through the design of a prospective model study, in which patients diagnosed with this condition who went to the outpatient department of Gastroenterology at Eugenio Espejo Hospital between June and September 2019 received a prescription for physical exercise. After three months, transaminase levels and their correlation with age, sex, volume and intensity of the exercise (data collected through self-assessment surveys) were analyzed as modulators of the final result.

#### RESULTS:

TGO decreases were observed in all patients with values between -2.27 and -57.78%, with the average change being -23.30%. ( $p = 0.031$ ). TGP values had an average change of -28.42%, but not statistically significant ( $p = 0.25$ ). The final TGO values were statistically significant in

relation to the age group, ( $\geq 50$  years old,  $p = 0.016$ ), but with TGP it was not relevant ( $p = 0.375$ ). There were no statistically significant correlations between the decrease in TGO and TGP with the rest of the variables.

**CONCLUSION:**

It was determined that the prescription of physical exercise decreased transaminasemia levels, one of the main markers of liver damage, in patients with NASH, predominantly TGO values, the rest of the variables did not have a demonstrable impact on the final results.

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**THE EVOLUTION OF HANDGRIP STRENGTH AND THE SELF-PERCEPTION OF STRENGTH AND PHYSICAL CONDITION IN CHILDREN AND ADOLESCENTS OF THE REGION OF MADRID**

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**INTRODUCTION:**

In the last years, muscular strength has emerged as a great indicator of future health in adolescents [1]. The evaluation and promotion of strength training in children and adolescents is a key factor in the development of physical condition at school and during leisure time. The aim of the present study was to describe the evolution of handgrip strength, as a general indicator of strength, through school years in the Region of Madrid. Additionally, to determine how they perceived their physical condition and the relation of their perceptions and the real strength data

**METHODS:**

As part of the PASOS (Physical Activity, Sedentarism and Obesity of Spanish Youth) Project, 436 (212 boys and 224 girls) children in Primary School (8-12 years,  $n=271$ ) and adolescents in Secondary School (13-17 years,  $n=165$ ) participated from the Region of Madrid. Handgrip strength of both hands was measured following the Alpha Fitness Battery protocol. The self-perception of physical condition was evaluated with the IFIS Scale. Mean values of handgrip strength for both hands were calculated and classified by age and gender in quintile areas (0:  $p80$ ), following European standards [2]

**RESULTS:**

Handgrip strength increased through the years in both sexes. From  $13.8 \pm 2.6$  Kg of handgrip strength (8-years group) to  $34.9 \pm 8.2$  Kg (16-year group) in boys, and from  $12 \pm 2.3$  Kg (8-year group) to  $26.8 \pm 1.3$  Kg (17-year group) in girls. Although when comparing the quintile classification with the previous standards there is a clear decline through the years, from  $2.73 \pm 1.5$  (8-year group) to  $0.92 \pm 0.8$  (16-year group) in boys, and from  $2.52 \pm 1.5$  (8-year group) to  $0.81 \pm 0.9$  (16-year group) in girls. The self-perception of strength had no significant correlation with the handgrip real data ( $r=-0.09$   $p=0.06$ ), but the quintile classification of the subject's strength was significantly related to self-perception in both sexes and age groups (Boys 8-12:  $r=0.43$ ;  $p=0$ . Boys 13-17:  $r=0.50$ ;  $p=0$ . Girls 13-17:  $r=0.39$ ;  $p=0$ ), except for the girls 6-12 ( $r=0.09$ ;  $p=0.35$ ). A very low but significant relation was also observed between perceived physical condition and strength classification ( $r=0.15$ ;  $p=0.002$ )

**CONCLUSION:**

Our data show a general decline in the quintile classification used as the standard in handgrip strength through the years, in both sexes. Also, a misperception of their real strength as they grow up (they perceive themselves stronger than they really are). This misperception in adolescence could be influencing the amount of strength work they do, as the relative strength they have is worse than in childhood. The physical condition self-perception has a poor correlation with real strength in all groups

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**COMBINED INFLUENCE OF HEALTHY LIFESTYLE HABITS ON HEALTH RELATED QUALITY OF LIFE IN ADOLESCENTS: DADOS STUDY**

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UNIVERSITAT JAUME I

**INTRODUCTION:**

Previous research in adolescents suggests that healthy lifestyle habits such as Mediterranean diet, sleep patterns or screen time are associated with Health Related Quality of Life (HRQL).1,2 However, to the best of our knowledge, no studies have analysed the combined effect of several healthy lifestyle habits on HRQL. The purpose of this study was to analyse the combined effect of physical activity (PA), adherence to the Mediterranean diet, sleep quality, sleep duration and screen time on HRQL in adolescents.

**METHODS:**

This is a cross-sectional analysis with 262 adolescents ( $13.9 \pm 0.3$  years) from DADOS study. PA was assessed with a wrist-worn GENEActiv triaxial accelerometer. The adherence to the Mediterranean diet was evaluated by the KIDMED questionnaire. Sleep patterns were self-reported through the Spanish version of Pittsburgh Sleep Quality Index questionnaire. Screen time was assessed through the HELENA sedentary behaviour questionnaire. HRQL was measured using the KIDSCREEN-10 questionnaire. A healthy lifestyle index, ranging from 0 to 5 points, was specifically defined for our sample according to the number of habits achieved by each adolescent: (1) high level of vigorous PA; (2) optimal adherence to the Mediterranean diet; (3) good sleep quality; (4) good sleep duration; (5) low screen time. One-way analysis of covariance (ANCOVA) was used to investigate whether HRQL differed depending on the number of healthy habits achieved. Additionally, logistic regression analysis was conducted to examine the likelihood of achieving high HRQL according to the number of

healthy habits achieved. Analyses were adjusted for sex, pubertal stage and waist circumference. The level of significance was set to  $p < 0.05$ .

**RESULTS:**

Adolescents achieving  $\geq 3$  healthy lifestyle habits showed higher HRQL levels compared to those fulfilling 0 ( $p < 0.05$ ). Logistic regression analysis revealed an increased likelihood of high HRQL according to the number healthy lifestyle index (i.e. 1 habit = OR: 3.33; 2 habits = OR: 3.73; 3 habits = OR: 3.81;  $\geq 4$  habits = OR: 4.53).

**CONCLUSION:**

Our results reveal higher levels of HRQL in those adolescents achieving  $\geq 3$  healthy lifestyle habits compared to their peers achieving none. Moreover, our findings show a cumulative positive effect of healthy lifestyle habits on HRQL. From a public health perspective, these findings underline the key role of promoting a healthy lifestyle in order to improve adolescents health and well-being.

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## OP-MH09 Physical activity and health

### EXERCISE, MENTAL HEALTH AND COVID-19 - THE ROLE OF EXERCISE IN TIMES OF ISOLATION, CONFINEMENT AND RESTRICTED PHYSICAL ACTIVITY

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**INTRODUCTION:**

Exercise intervention studies provide evidence for the counteracting effect on sleep and mental health, while the most efficient exercise protocol still needs to be defined. However, intervention studies turning the table by isolating and/or confining people or restricting physical activity or exercise habituation are rare, but might help to develop strategies or treatments in special situations like the present COVID-19 pandemic crises. It was hypothesized that (1) exercise participation during isolation/confinement supports, that (2) daily exercise might surpass every second day exercise and that (3) a forced stop of habitual exercise impairs sleep and mental health moderated by underlying electrocortical brain activity and endocrine parameters.

**METHODS:**

Two groups were confined and isolated for a month within the Human Exploration Research Analog (HERA), Johnson Space Centre Houston, Texas, US. These isolated groups simulated a mission to space and executed daily (Iso-100%) or every second day (Iso-50%) exercise training alternating between biking and stretching & toning. The exercise control group (ExCTRL, N=17) followed the same daily exercise protocol as group Iso-100, while the non-exercise control group (NoExCTRL, N=10) stopped their habitual exercise training, both for a month under non-isolated conditions. Training and sleep logs, actigraphy, sleep questionnaires (SSA), affect (PANAS-X), cognitive performance, resting brain cortical activity (EEG) and morning cortisol were assessed prior, during and after intervention. Study was approved by the Institutional Review Board (NASA) and University ethic committee. Mixed model ANOVA and Bonferroni correction was used.

**RESULTS:**

Both isolated groups showed a significant increase in morning cortisol during isolation compared to baseline and after isolation (all  $p < .05$ ). Iso-100% showed higher cortisol as Iso-50%, while control groups did not show any differences (group & interaction  $p < .001$ ). Significant lower positive affect scores were obtained in group Iso-100 and NoExCTRL group on day 28 (time ( $p < .001$ ), interaction ( $p = .040$ )). EEG beta frequency activity decreased during isolation compared to pre and post especially for isolated groups ( $p < .05$ ). NoExCTRL group did show increased somatic complaints and EEG alpha activity and impaired sleep and awakening quality, positive affect and cognitive performance (all  $p < .05$ ), while ExCTRL remained stable in all parameters.

**CONCLUSION:**

Results support the notion that exercise training does support mental health and sleep during a month of isolation and confinement, while no difference between daily or every second day exercise regimen was found. This benefit is even more evident taking NoExCTRL group into account showing considerable deteriorations in sleep and mental health along a month of exercise abstinence. Regular exercise participation might help people to cope with extreme situations like COVID-19 crises combining restricted physical activity and isolation/confinement.

### PREVALENCE OF OVERWEIGHT/OBESITY IN RELATION TO DIETARY HABITS AND PHYSICAL ACTIVITIES 7-11 YEARS OLD CHILDREN IN LATVIA

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**INTRODUCTION:**

Overweight and obesity rates are still raising in parallel with increased consumption of high energy dense foods, drinks and inactive lifestyle causing health issues such as diabetes, cardiovascular and musculoskeletal diseases, and cancer of gallbladder, liver, kidney, colon, breast and ovarian also in younger population. The aim of this study was to determine the prevalence of overweight/obesity among children in Latvia and to assess its association with dietary habits and physical activities.

**METHODS:**

1788 children (age 7 – 11 years) from 70 schools in Latvia were enrolled in the study. Anthropometric data (body mass index (BMI), waist circumference (WC)) were measured by standard procedures. According to the WHO BMI percentile scale children were divided into four groups: underweight (UW) (n=81), normal (NOR) (n=1190), overweight (OW) (n=155) and obese (OB) (n=219). Study participants filled out questionnaires about physical activity and nutritional habits. Data were processed with SPSS 22.

**RESULTS:**

It was determined that 9% of boys were overweight, 15,5% were obese, while 9.9% of girls were overweight, and 10,7% were obese. Obesity prevalence was found to be significantly higher in boys compare to girls ( $p < 0,05$ ). Statistical analysis showed that children in OB

group skipped breakfast more often, than children in NOR or UW group (29%; 22,4%; 18%% correspondingly). Only 10,8% of all children choose to eat 5 or more recommended portions of vegetable in the day, 63,8% of children eat 2 or less portions in the day. The OB group chooses to eat less vegetables comparison with NOR and OW group ( $p<0,05$ ). Data showed that in OW group snacking with salted and sweetened snacks correlate with WC ( $r=0,254$ ,  $p<0,01$ ). Self-reported higher physical activity level was not determining lower weight, BMI or WC ( $p>0,05$ ), nor any of the measured nutritional parameters (e.g. consumption of complex carbohydrates, more frequent meals or snacks).

**CONCLUSION:**

The prevalence of obesity among 7-11 years old Latvian children is in accordance with global trends reported by WHO (ranging from 5% to 9% in either sex) and was more prevalent in boys. Skipping the breakfast and not eating enough vegetables were found to be associated with children's overweight/obesity. Self-reported physical activity levels did not influence anthropometric measurements in this age group.

**TAKING PHYSICAL EDUCATION CLASS "THE DIET FITNESS COURSE" HAS A FAVORABLE IMPACT ON UNIVERSITY STUDENTS' BODY COMPOSITION**

SUGIURA, K.

RIKKYO UNIVERSITY

**INTRODUCTION:**

In modern Japan, physical inactivity of young people has become a serious problem. If such young people come out of society without exercise habits, they may increase the risk of future obesity and lifestyle-related diseases. The purpose of this study, therefore, was to evaluate the influence of a specific physical education class on non-active university students' body composition.

**METHODS:**

Fourteen male students (male; height  $169\pm 3$  cm, weight  $64.0\pm 7.4$  kg, BMI  $22.5\pm 2.5$ ) and forty female students (female; height  $157\pm 4$  cm, weight  $51.2\pm 4.2$  kg, BMI  $20.7\pm 1.4$ ) who attended the class were recruited as participants. The class was conducted once a week for fourteen weeks and included 30-minute lectures and 60-minute exercises (stretching, stabilizer ball, machine and dumbbell exercises, bicycle ergometer, walking, step-exercises, and yoga. The subjects set goals for improving their body composition and documented their exercise every week. Body composition (body weight, BMI, %FAT, fat mass, and muscle mass) was measured using a multi-frequency segmental body-composition analyzer (TANITA MC-780A-N, Japan).

**RESULTS:**

A significant decrease was observed in %FAT and fat mass in both the male and female participants across two periods ( $p<0.001$ ). Six of eight female students whose %FAT was over the healthy upper limit (30.0%) saw a decrease of %FAT to favorable state.

**CONCLUSION:**

The results of this study suggest that this specific type of physical education class motivated non-active university students' to increase their exercise behavior and activity levels.

**MODERATE PHYSICAL ACTIVITY IN 4TH AND 6TH YEAR'S MEDICAL STUDENTS: WHAT DOES IT GIVE FOR THEM?**

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TULA STATE UNIVERSITY

**INTRODUCTION:**

Modern medical students are at risk for development health impairment not only due to intense academic curriculum, but also to sedentary lifestyle and social media use. Physical exercise classes 2 times per week are mandatory only for 1-3 year students, and afterwards only some students remain be physically active.

**METHODS:**

To assess participation in physical activity (PA) and investigate health benefits while studying in medical school we have compared data of heart rate variability (HRV) and psychophysiological testing obtained in autumn 2016 and spring 2019 in the same cohort of 4th and 6th - year medical students.

**RESULTS:**

Among 42 males 4th - year students moderate/vigorous PA reported 19 (45.2%), among 92 females were active 31 (33.7%). 2.5 years later percent of students met WHO recommendations has been significantly increased: 71.6% of 38 males and 64.1% of 92 females were engaged in PA, predominantly strength training, aerobic training and soccer.

Active students demonstrated greater HRV that means greater adaptive functional reserve. In autumn 2016 in PA students of both gender HR was lower ( $77.2\pm 3.1$  (M $\pm$ m) vs  $83.6\pm 2.0$  bpm in males;  $p=0.047$ ;  $79.5\pm 2.2$  vs  $84.5\pm 1.5$  bpm in females;  $p=0.031$ ). In females pNN50% was significantly bigger ( $22.9\pm 3.8$  vs  $15.6\pm 2.1$ %;  $p=0.04$ ). In the last semester before accreditation females participated in PA had greater total power of HRV ( $p=0.039$ ) and power of high frequency (HF) band ( $p=0.029$ ), whereas males – greater pNN50% ( $11.3\pm 2.4$ % vs  $5.1\pm 1.3$ %;  $p=0.016$ ) and tendency to increasing HF. No differences were found in blood pressure level.

Visual working memory was in 4th year both active males and females better and self-rated health higher ( $p=0.006$  and  $p=0.0048$ ) than in those with low PA. High level of PA positively associated with desire to learn in females and negatively - with difficulty learning in males.

In male-students evaluated during their 6th year PA positively influence on social and psychological status. Active males reported less smoking and alcohol use, higher health self-esteem ( $p=0.0046$ ), desire and easiness to learn and were more likely morning-type subjects. Grade point average was tended to be higher only in males ( $p=0.063$ ). No differences were found in lifestyle behavior in 6th year females.

**CONCLUSION:**

Thus, moderate/vigorous PA has some health benefits in contemporary medical students and should be promoted, especially in males.

**ASSOCIATIONS BETWEEN PHYSICAL AND PSYCHOLOGICAL HEALTH OF TENNIS AND NON-TENNIS PLAYERS.**

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LIVERPOOL HOPE UNIVERSITY

**INTRODUCTION:**

In order to provide guidelines for healthy living and ageing Cox and Sparham (2013), outlined the effects of regular physical activity on both physical and mental health, including a healthier body weight, reduced risk of type 2 diabetes and cardiovascular disease, increased well-being, lower stress levels, and prevention of anxiety and depression. In addition, Clow and Edmunds (2014), speculated whether the de-

gree of benefit may vary depending on the type and mode of physical activity. They maintained the strongest increases in health benefits were in individuals engaging in lighter, moderate to vigorous exercise, in contrast to individuals training for sport, who experienced comparatively less health benefits, likely owing to increased rate of injury. The aim of the present study was to investigate a range of health markers and psychological variables in a group of generally active individuals versus a group of recreational tennis players.

#### METHODS:

90 participants, aged 18-65 years, took part in this study 43 tennis players (18 m, 25 f) and 47 non-players (26 m, 21 f). Physical health markers consisted of traditional cardiometabolic risk (CMR) indices including: systolic blood pressure, triglycerides, ratio of total cholesterol to high density lipoproteins, percentage body fat, glycated haemoglobin and cardiorespiratory fitness. All indices were then standardised, controlling for gender, and clustered to provide a single score of CMR. Psychological variables were assessed via multiple questionnaires, including: profile of mood states, depression anxiety stress scales, positive and negative affect schedule, and 12-item short form health survey. Relationships between each scale and CMR were analysed using linear regression.

#### RESULTS:

Regression analyses revealed a significant link, for the tennis sample only, between physical health (SF-12) and CMR,  $F(1, 88) = -2.24, p < .05$ . For the remaining variables no significant links were found for the tennis sample, however the non-tennis sample showed significant results for depression ( $F(1, 88) = 3.18, p < .01$ ), confusion ( $F(1, 88) = -2.75, p < .05$ ), stress ( $F(1, 88) = -2.39, p < .05$ ), and positive ( $F(1, 88) = -2.39, p < .05$ ) and negative ( $F(1, 88) = -2.65, p < .05$ ) affect.

#### CONCLUSION:

In conclusion, the results of the current study indicate that exercise and physical activity have a number of mutually beneficial effects in conjunction with physical and mental health. These findings mainly corroborated engagement in general physical activities, and not necessarily within the tennis domain. Future research should inquire in more detail whether mental and physical health benefits can be achieved in the domain of tennis. Particularly, since a large number of the population engage in this sport across all age groups.

#### References

- Cox, S. & Sparham, P. 2013. Sports Club Survey, Sport and Recreation Alliance, London.  
Clow, A. & Edmunds, S. 2014. Physical Activity and Mental Health, Human Kinetics, Champaign, IL.

### APPLICATION OF HEALTH RISK IN EVALUATION OF HEALTH-RELATED PHYSICAL FITNESS AMONG CHINESE ADULTS AGED 40-59 YEARS

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#### INTRODUCTION:

Background: Unhealthy lifestyle and living environments result in the increase of global non-communicable disease and health risk. It becomes one of the important concerns to improve the fitness health, reduce the risk of disease and maintain a high level of health by implementation of scientific fitness guidance. This study aims to explore the relationship between health-related physical fitness (HRPF) and health risks among the middle-aged population in China, by using health risk degree as a ruler to scale the HRPF. This study would initially formulate a comprehensive evaluation of HRPF and provide evidence for fitness measurement and evaluation.

#### METHODS:

This cross-sectional study consisted of two samples: 1759 (42% males) Chinese adults aged 40-59 years in sample 1 and 115 (48% males) in sample 2. (1) Sample 1 was treated as the test group. HRPF were measured, including cardiorespiratory endurance by VO<sub>2</sub>max, body fat percentage by bioelectrical impedance analysis, muscle strength by grip strength, muscle endurance by 1 minute sit-up test and load elbow flexion, flexibility by sit and reach, mental state by questionnaire. The weighted scores of HRPF were calculated. Five health risks were measured, including blood pressure, BMI, waist-circumference, blood lipid, blood glucose. Health risk clustering and stratification scale were obtained based on these five tests. One point was scored if test value reached out of normal range, while, 2 points were given for hypertension medication. The health risk scored 0 to 6. Using such health risk scale, comprehensive grade of HRPF was evaluated. (2) Sample 2 was the validation group: back substitution was performed in sample 2 of 115 adults.

#### RESULTS:

(1) HRPF score in sample 1 showed significant differences in different gender and age groups ( $P < 0.05$ ). Percentage of health risk with 0 to 6 degrees was 18.9%, 20.5%, 33.5%, 8.7%, 8.4%, 4.0%, and 6.0%, respectively. Higher health risks were found in females ( $\eta^2 = 32.0, p < 0.01$  compared with males) and elders ( $\eta^2 = 13.3, p < 0.05$  compared with youngsters). With the increase of health risk degree, the overall grade of HRPF was reduced accordingly ( $r = 0.025, p < 0.05$ ). (2) The results of back substitution in sample 2 showed that overall grade of HRPF in each health risk group were in good consistency with the results in sample 1 ( $Kappa = 0.760-0.771, p < 0.001$ ).

#### CONCLUSION:

The HRPF and health risk degree were reversely associated, with being sensitive to the age and gender groups. Health risk degree could provide reference for the quantitative data of a comprehensive evaluation of physical fitness and disease prevention for Chinese adults aged 40 - 59 years.

### REFERENCE VALUES FOR HANDGRIP STRENGTH IN THE OLDER ADULTS IN BOGOTÁ-COLOMBIA

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#### INTRODUCTION:

The increase in the population of older adults in the world represents a challenge for public health policies in each country; aging brings with it sarcopenia, caused by the loss of muscle mass, which produces a reduction in muscle strength and function, increasing the risk of decreasing the functionality of the elderly. This geriatric syndrome is progressive and widespread and can lead to disability, hospitalization, worsening quality of life and death (1). According to the consensus of the European Working Group on Sarcopenia in the Elderly (EWGSOP) (2), the measurement of hand grip strength (HGS) is the simplest and recommended method for assessing muscle strength, nutritional status and as an early marker on the morbidity and mortality of cardiometabolic disease (3). The aim of this study was to determine the normative reference values of handgrip in the older adults.

#### METHODS:

Cross-sectional descriptive observational study. The convenience sample was drawn from 1000 older adult women from the city of Bogotá, aged between 60 and 84, participated in the study. Maximal isometric HGS of the dominant hand was evaluated using a hand



dynamometer. Anthropometric measurements as weight, height and body mass index were obtained using standard techniques. A univariate descriptive analysis and a correlation analysis between hand grip strength and age. Mean, standard deviation and statistical tests were used to compare grip strength means by groups, p-Values less than 0.05 were considered statistically significant. Normative values for HGS were calculated and expressed as tabulated percentiles from 3 to 97 (P3, P10, P25, P50, P75, P90 and P97).

**RESULTS:**

For the analysis of HGS values, a percentage distribution was made, obtaining percentiles from P3 to P97; It is established that 50% of the population has an average of 18.6 kg of muscular strength. The P3 indicates a low level of strength, with an average of 11.1 kg in all age ranges; Finally, the P97 establishes an average of 24 kg that indicates a better performance in daily life activities.

**CONCLUSION:**

This paper presents the reference values of HGS in female older adults of Bogotá. The testing of muscle strength at older adults should be included as predictor the risk future in diseases as sarcopenia and dynapenia.

1- Cawthon, P., Fox, K., Gandra, S., Delmonico, M., Chiou, C., Anthony, M. & Harris, T. (2009). Do muscle mass, muscle density, strength, and physical function similarly influence risk of hospitalization in older adults?. *Journal of the American Geriatrics Society*, 57(8), 1411-1419. 2- Cruz-Jentoft A, Baeyens J, Bauer J, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. *Age Ageing* 2010; 39 (4): 412-23. 3- Günther, C. M., Bürger, A., Rickert, M., Crispin, A., & Schulz, C. U. (2008). Grip strength in healthy caucasian adults: reference values. *The Journal of hand surgery*, 33(4), 55.

**OP-PN01 Thermoregulation****POST-EXERCISE HOT-WATER IMMERSION DOES NOT FURTHER ENHANCE HEAT ADAPTATION OR PERFORMANCE IN ENDURANCE ATHLETES TRAINING IN A HOT ENVIRONMENT**

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*SOUTHERN CROSS UNIVERSITY*

**INTRODUCTION:**

Hot-water immersion (HWI) after training in temperate conditions has been shown to induce thermophysiological adaptations and improve endurance performance in the heat, however, the potential additive effects of HWI and training in hot outdoor conditions remain unknown. Therefore, this study aimed to determine the effect of repeated post-exercise HWI in athletes training in a hot environment.

**METHODS:**

Thirteen (9 female) elite/pre-elite partially heat acclimatized racewalkers completed a 15-day training program in outdoor heat (mean afternoon high temperature=34.6°C). Athletes were divided into two groups matched for VO<sub>2</sub>max and 10,000 m walking performance time that completed either HWI (40°C for 30-40 min) or seated rest in 21°C (CON), following 8 training sessions. Pre-post testing included a 30-min fixed-intensity walk in heat, laboratory incremental walk to exhaustion and 10,000 m outdoor time-trial.

**RESULTS:**

Training frequency and volume was similar between groups (P=0.54). Core temperature was significantly higher during immersion in HWI (38.5 ± 0.3) than CON (37.8 ± 0.2°C; P<0.001). There were no differences between groups in resting or exercise rectal temperature or heart rate, skin temperature, sweat rate, or the speed at Lactate Threshold 2, VO<sub>2</sub>max or 10,000 m performance (P>0.05). There were significant (P<0.05) pre-post differences for both groups in submaximal exercising heart rate (~11 bpm) sweat rate (0.34-0.55 L.h<sup>-1</sup>) and thermal comfort (1.2-1.5 arbitrary units), and 10,000 m racewalking performance time (~3 min).

**CONCLUSION:**

After a 15-day heat training intervention, we observed significantly improved submaximal exercising heart rate, sweat rate, and thermal comfort, as well as improved 10,000 m racewalking performance in both groups. However, the addition of HWI did not further enhance heat adaptation or performance in partially heat-acclimatized athletes. Physiological adaptation appeared to be optimized from training in hot conditions alone.

**THE EFFECT OF INCREASING AMBIENT TEMPERATURE ON CYCLING TIME TRIAL PERFORMANCE**

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*UNIVERSITY OF CANBERRA*

**INTRODUCTION:**

Prolonged self-paced cycling is impaired in hot relative to cool conditions and characterised by a progressive decline in power output.<sup>1,2</sup> Reductions in performance under heat stress have been attributed to an increase in cardiovascular strain, mediated by a rise in whole-body temperature, which leads to gradual decreases in VO<sub>2</sub>max.<sup>2</sup> To date, one study has investigated the impact of a range of ambient temperatures (17 to 32°C) on cycling time trial performance.<sup>3</sup> However, athletes often compete in a wider range of climates. Thus, we examined the effect of increasing ambient temperature from 13 to 36°C on self-paced cycling and the associated thermal, physiological and perceptual responses. To target the effect of ambient temperature, relative humidity (RH) was manipulated to create similar skin-to-air vapour pressure gradients between conditions.

**METHODS:**

Fourteen trained (VO<sub>2</sub>max: 5.0 ± 0.4 L·min<sup>-1</sup>), un-acclimatized male cyclists performed four 30 km cycling time trials on separate days in COOL (13°C, 44% RH), TEMP (20°C, 70% RH), WARM (28°C, 78% RH) and HOT (36°C, 72% RH) conditions. Core and skin temperature, heart rate, cardiac output, thermal comfort and rating of perceived exertion were measured throughout.

**RESULTS:**

Mean power output (MPO) was lower in HOT (~228 W) than COOL (~275 W), TEMP (~272 W) and WARM (~262 W) (P<0.01); lower in WARM than COOL and TEMP (P<0.01); but similar in COOL and TEMP (P>0.05). Peak core temperature was higher in HOT (~39.6°C) than COOL (~38.7°C), TEMP (~38.8°C) and WARM (~39.1°C) (P<0.01); higher in WARM than COOL (P<0.01) and TEMP (P<0.02); but similar in COOL and TEMP (P=0.80). Mean skin temperature differed across trials (P<0.01), in line with ambient temperature. Heart rate was higher in HOT than COOL, TEMP and WARM (P<0.01), and higher in TEMP and WARM than COOL (P<0.01). Cardiac output was lower in HOT than COOL, TEMP, and WARM (P<0.01), and lower in WARM than TEMP (P<0.01). Ratings of perceived exertion were higher in HOT than all trials (P<0.01) and higher in WARM than TEMP (P<0.01). Thermal discomfort was higher as ambient temperature increased (P<0.01).

**CONCLUSION:**

Despite a similar absolute increase in ambient temperature ( $\sim 8^{\circ}\text{C}$ ) between time trials, MPO did not decrease in a stepwise manner. Indeed, a similar MPO was observed in COOL and TEMP, a  $\sim 5\%$  decrease occurred in WARM relative to TEMP, and a  $\sim 13\%$  reduction was noted in HOT compared to WARM. The exacerbated decrement in performance in the HOT trial was associated with a higher core and skin temperature, and an elevated heart rate. Our results indicate that cycling performance is maintained in ambient temperatures ranging from 13 to  $22^{\circ}\text{C}$ , however, decreases exponentially as temperature increases to  $36^{\circ}\text{C}$ . The decrement in performance is associated with marked elevations in thermal and cardiovascular strain.

1 Tatterson et al. *J Sci Med Sport* 3, 186–193 (2000)

2 Périard et al. *Exp. Physiol.* 96, 134–144 (2011)

3 Peiffer & Abbiss. *Int J Sports Physiol Perform* 6, 208–220 (2011)

### **EFFECTS OF SEX DIFFERENCES ON EXERCISE CAPACITY AND THERMOREGULATION TO PRE-COOLING WITH ICE SLURRY INGESTION IN A HOT ENVIRONMENT**

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**INTRODUCTION:**

Male and female have different responses to thermal stress. Body cooling is particularly important for female in the heat because the heat dissipation ability in female is lower than that in men. Ice slurry ingestion is widely used for pre-cooling in the sports field (Périard, J D et al. 2017). Despite many reports suggesting that precooling with an ice slurry improves endurance performance in male (Tan, P M S et al. 2015), no effect has been reported in female (Zimmermann M et al. 2015,2017). The present study examined sex differences in exercise capacity and thermoregulation responses after ice slurry ingestion in a hot environment.

**METHODS:**

Eight males and eight females completed two trials in a random order: 7.5 g/kg 1) ice slurry (ICE) and 2) control water (CON). Both beverages contained 5.7% carbohydrate. The subjects ingested each drink divided into 6 times within 30 min before cycling at 55%  $\text{VO}_{2\text{peak}}$  until the rectal temperature ( $T_{\text{re}}$ ) reached  $38.5^{\circ}\text{C}$  or exhaustion ( $38^{\circ}\text{C}$ ; 40%RH). The  $T_{\text{re}}$ , heart rate (HR), skin temperature ( $T_{\text{sk}}$ ), rating of thermal sensation (TS), thermal comfort (TC), rating of perceived exertion (RPE), metabolic heat production (M), and exercise time were measured.

**RESULTS:**

The exercise time in the ICE trial was significantly longer for female than for male ( $p = 0.040$ ), but no differences were noted in the CON trial ( $p = 0.454$ ). There were no sex differences in the  $T_{\text{re}}$ ,  $\Delta T_{\text{re}}$ ,  $T_{\text{sk}}$ , and RPE ( $p > 0.05$ ). However, there were main effects of sex on the TS and TC in both trials. The mean TS and TC were significantly higher (feeling hot and uncomfortable) in male than in female ( $p < 0.05$ ). The mean M during exercise in the ICE trial was significantly higher in male than in female ( $p = 0.040$ ), but no differences were noted in the CON trial ( $p = 0.070$ ).

**CONCLUSION:**

The present study showed that exercise time may be longer for female than for male when pre-cooling with ice slurry ingestion. In exercises of the same relative intensity (55%  $\text{VO}_{2\text{peak}}$ ), the pre-cooling effect may have been sustained in female compared with that in male because of lower heat production (M) during exercise in female. Previous studies have shown that female is more sensitive to cooling than male (Kaikaew K et al. 2018). In the present study, the TS was lower for female than for male. The TS during ice slurry ingestion may have influenced the subsequent exercise. This study demonstrates that male and female respond differently to exercises of the same relative intensity following pre-cooling with ice slurry ingestion, especially perceived indicators and metabolic heat production.

### **SHORT-TERM REPEATED-SPRINT TRAINING IN THE HEAT: AN ACCLIMATION APPROACH FOR TEAM-SPORT ATHLETES**

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**INTRODUCTION:**

Exercise-heat acclimation is used by endurance athletes to optimise performance when competing in the heat [1]. However, the training required to enhance heat tolerance and optimise performance in team-sport athletes may differ to that commonly prescribed for endurance athletes. For example, in sports such as rugby sevens, soccer and field hockey, high-level performance involves the ability to repeat maximal or near-maximal sprint efforts [2]. Moreover, the training time and travel constraints of high-level team-sport athletes are such that prolonged (>7 days) interventions may be difficult to implement during the regular season [3]. As such, this study compared the performance and physiological adaptations of short-term repeated-sprint training in HOT ( $40^{\circ}\text{C}$ ) and COOL ( $20^{\circ}\text{C}$ ) conditions in team-sport athletes.

**METHODS:**

Twenty-five trained males completed 5 cycle ergometer training sessions over 7 days in HOT ( $n=13$ ) or COOL ( $n=12$ ). The sessions consisted of a submaximal warm-up followed by 4 sets of 5  $\times$  6-s maximal sprints with 24 s recovery and 5 min between sets. Before and after the training intervention intermittent shuttle running performance were assessed in cool conditions and repeated-sprint ability was assessed in the heat. Neuromuscular function testing of the knee extensors was undertaken before and after each repeated-sprint ability assessment

**RESULTS:**

Shuttle running distance increased after both interventions ( $P < 0.001$ ), with a non-significant ( $P = 0.131$ ) but larger effect in HOT (315 m,  $d = 1.18$ ) than COOL (207 m,  $d = 0.51$ ). Mean ( $\sim 7\%$ ,  $P < 0.001$ ) and peak ( $\sim 5\%$ ,  $P < 0.05$ ) power during repeated-sprinting increased following both interventions. Peak twitch force before the repeated-sprint assessment was  $\sim 10\%$  lower after both interventions ( $P = 0.001$ ). Heart rate during the repeated-sprint warm-up was lower after both interventions ( $P < 0.001$ ), with a larger but non-significant effect ( $P = 0.591$ ) observed in HOT ( $\sim 8$  beats.min $^{-1}$ ,  $P < 0.001$ ,  $d = -0.49$ ) than COOL ( $\sim 4$  beats.min $^{-1}$ ,  $P = 0.006$ ,  $d = -0.22$ ). Rectal temperature during the repeated-sprint assessment was lower following both interventions ( $P < 0.001$ ), with larger effects in HOT than COOL during the warm-up ( $P = 0.082$ ;  $d = -0.53$  vs.  $d = -0.15$ ) and repeated-sprints ( $P = 0.081$ ;  $d = -0.54$  vs.  $d = -0.02$ ). Skin temperature ( $P = 0.004$ ,  $d = -1.11$ ) and thermal sensation ( $P = 0.015$ ,  $d = -0.93$ ) were lower during the repeated-sprints after training in HOT than COOL. Sweat rate increased (0.2 L.h $^{-1}$ ) after training in HOT ( $P = 0.027$ ;  $d = 0.72$ ).

**CONCLUSION:**

Five sessions of repeated-sprint training in hot and cool conditions over 7 days improved repeated-sprint ability in the heat and enhanced 20-m shuttle running performance in cool conditions. Both training interventions induced an adaptive response, with more pronounced thermal adaptations emerging after training in the heat.

1 Périard et al. *Scand J Med Sci Sports*. 2015;25:20-38.

2 Girard et al. *Scand J Med Sci Sports*. 2015;25:79-89.

3 Chalmers et al. *Sports Med*. 2014;44:971-88.

### **EFFECTS OF THREE-EXERCISE SESSIONS IN THE HEAT ON ENDURANCE CYCLING PERFORMANCE.**

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*CERISM - UNIVERSITY OF VERONA*

#### **INTRODUCTION:**

Many sporting events are held every year in hot environments (i.e. 35°C, 50%RH). In order to limit heat-induced performance decrements, heat acclimatization/acclimation (HA) protocols have been proposed<sup>1</sup>. Although complete physiological adaptation to hot environments may require up to 14 days to occur<sup>1</sup>, cardiovascular and perceptual adaptations have been noticed even after only 3 days of heat exposures<sup>2</sup>. Despite being short-term acclimations protocols of interest to elite athletes, the expected performance enhancements, as well as the physiological adaptation induced by this kind of programs are not completely understood. In this study, we investigated the effects of a 3-day very short-term heat acclimation protocol (VSTAP) on performance, physiological and perceptual responses to exercise in the heat.

#### **METHODS:**

9 well trained male cyclists (age: 30.9±8; weight: 73.2±7) performed a preliminary normothermic (18°C- 50% RH) maximal cardiopulmonary exercise test (CPET) to define individual Peak Power Output (PPO). CPET was followed by normothermic and a hot (35°C-50% RH) Time to Exhaustion Tests (nTTE, hTTE) at 75% of PPO. TTEs were repeated after the VSTAP, consisting of 3 days- 90 min training at 50% of PPO in the heat (35°C-50% RH). During TTE tests, final performance time (PT), blood lactate [La], maximal and mean Heart Rate (HR), Rate of Perceived Exertion (RPE), Thermal Sensation (TS) and Ear Temperature (Et) were evaluated. Moreover, we monitored HR, TS, RPE and Et throughout the training sessions (T1,T2,T3). All data from TTE and training sessions were analyzed using ANOVA for repeated measures. Performance data were also analyzed using magnitude based inferences (MBI).

#### **RESULTS:**

TTE performance tends to increase at POST in H (+26%). MBI revealed larger performance improvements in H compared to N (89/10/1 %chances of positive/trivial/negative effect). No effect of time was reported on Et or TS, which were higher in H (p<0.05). Regarding training measurements, HR decreased during T3 compared to T1 (p<0.05), and a similar trend was seen also for Ts and Et (-8% and -0.5°C, respectively). No changes in mean RPE throughout training sessions were seen.

#### **CONCLUSION:**

The VSTAP induced meaningful positive improvements to maximal performance in the heat. Moreover, improved thermoregulatory and perceptual responses (decreased Et and improved TS) and cardiovascular adaptations (decreased HR) during sub-maximal exercise were noticeable after just 3 days of training in the heat.

1. Tyler CJ et al.; *Sport Med*. 2016;

2. Chalmers S, et al. *Sport Med*. 2014.

### **ACCLIMATATION PROCESS TO WALK RACE ATHLETES IN IAAF WORLD ATHLETICS CHAMPIONSHIPS, DOHA 2019**

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*UNIVERSITY OF COIMBRA*

#### **INTRODUCTION:**

As it is known, in September the temperature and humidity in Doha are extremely high, even during the night. At the start of the 50Km walk race competition, air temperature was about 32°C and relative humidity was 81%, resulting in value of the Wet Bulb Globe Temperature (WBGT) thermal stress indicator close to 30°C, already in the dangerous category. With this warning, the acclimatization becomes essential in an athletes sports preparation, not only to improve his sport performance but also to preserve his integrity.

#### **METHODS:**

Tests were carried out in the climate chamber (CC). The indoor environmental conditions within the CC were imposed through control of the air and inner wall temperatures, with indoor air velocities lower than 1.9 m s<sup>-1</sup>. A treadmill was used to perform Vo<sub>2</sub>max tests on the 1st day of each acclimatization period. A gas analyser has been used to setup the work intensity of the following acclimatization sessions (60% of VO<sub>2</sub> max). Before and after all sessions, urine density and temperature, body mass and heart rate variability(hrv) were measured. In addition, heart rate(hr) and lactate concentration, fluid consumption, loss of plasma volume and percentage of loss of body mass throughout each session were controlled. The tested athlete underwent 15 sessions divided by three periods spaced 26 and 29 days apart.

#### **RESULTS:**

From the beginning till the end of the acclimatization, a rise of 3.8% in the athlete's velocity has been noticed, for the same % of VO<sub>2</sub> max. The Vo<sub>2</sub> decrease around 2.7 ml/kg/min between the 1st and the 3rd period. Additionally, between the 1st day of the 1st period and the 1st day of the 3rd period, the ventilation diminish in average 10 l/min and The Hr 3 bpm per stage in the VO<sub>2</sub> max protocol. From the 1st day to the last day the liquid ingestion increasing by 630 ml, the plasma volume loss varied from 7.14% to 0.85%, sweat rate increased 830 ml/h, Urine density decreased from 1013 to 1007.5, and the hr decreased from 131 to 124 bpm. The core temperature after the exercise did not have large variations, despite the slight increase in intensity between the different periods. Average value of core temperature along the sessions has been 38.11°C ±0.17°C. Furthermore, core temperature was maintained at 1.06±0.24°C above the initial temperature. Mean blood lactate was 1.39 ± 0.46 mmol/l. There were also differences in Hrv, with a decrease in ratio (LF: HF) from 7.76 ms<sup>2</sup> to 1.09ms<sup>2</sup>, Mean RR increased from 761 ms to 1059ms.

#### **CONCLUSION:**

Acclimatization process increase the efficiency, verified through a lower hr and higher hrv, lower sympatho-vagal presence, higher liquid ingestion, decrease in Vo<sub>2</sub>, lower ventilation, decrease in plasma volume lost and decrease in urine density. In conclusion, efficiency gains and a lower sympatho-vagal reflected in the physiologic response has been verified. Thus, it is fundamental in the preparation of athletes mainly in the case of competitions being held in extreme environmental conditions.

**AGILITY AND CHANGE OF DIRECTION PERFORMANCES DIFFERENTLY DEVELOP DURING REPEATED TRIALS**

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**INTRODUCTION:**

Agility is the ability to change velocity and direction in response to an external stimulus. Agility and change of direction (COD), the latter without response to external stimuli, were shown to be two different abilities [1]. Therefore, the aim of this study was to investigate whether these two abilities' performances differently develop during the execution of repeated trials.

**METHODS:**

After the warm-up, sixteen amateur soccer players (age =  $19.5 \pm 1.8$ ; height =  $180.1 \pm 6.4$  cm; body mass =  $74.5 \pm 7.8$  Kg) performed 20 consecutive agility and 20 consecutive COD repetitions in a counterbalanced crossover design in two different session days. In the agility test (Y-shaped), participants had to sprint for 5 meters, and then perform a 45° change of direction to the right or left for further 5 meters, according to a light stimulus. The test has already been shown to be reliable [2]. The spatial configuration of the COD test was the same of the agility, but participants already knew before the start whether they had to change direction to the right or left. The recovery time between each repetition was 20 seconds. Ratings of perceived exertion (RPE, Borg CR10) were collected after the 5th, 10th, 15th and 20th repetition during both the Agility and COD tests. Due to this, we divided the 20 repetitions into 4 blocks (1-5, 6-10, 11-15, 16-20 repetitions, respectively) for analysis. Repeated measures ANOVA was used to assess differences in performance between the first block and the following ones for agility. Friedman test was applied for the same analysis for COD tests. T-test and Wilcoxon test were then respectively applied where appropriate.

**RESULTS:**

For the agility condition, no differences in performance were found between the first block and the following ones ( $p = 0.432$ ). For the COD condition, the Friedman test revealed significant differences between the blocks ( $p = 0.018$ ). Wilcoxon test revealed that the fourth block was significantly faster than the first one ( $p = 0.001$ , Cohen's ES = 0.42 moderate,  $\Delta$  time = - 1.93 %).

**CONCLUSION:**

The performance in repeated agility trials remained stable throughout the 4 blocks. Instead, the COD performance slightly improved throughout the blocks. Therefore, 20 seconds of recovery (1:8 work:rest ratio) between each repetition were sufficient to maintain performance in agility, and to improve it in COD. Accordingly, RPE values show that participants rated the final exertion as "easy" for both conditions, suggesting that they did not experience fatigue. In conclusion, repeated agility and COD performances develop in different ways, supporting previous findings demonstrating that they are two different abilities. It appears interesting for future research to investigate, using a more fatiguing work:rest ratio, if fatigue differently develops between these two tasks.

**REFERENCES:**

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**THERMOREGULATORY RESPONSES OF INDIVIDUALS WITH A SPINAL CORD INJURY DURING WHEELCHAIR RUGBY- AND BASKETBALL-GAMES**

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**INTRODUCTION:**

The human bodies temperature is controlled by the thermoregulatory center in the hypothalamus, which triggers the corresponding efferent answer to an afferent input. A spinal cord lesion results in an altered control of different physiological mechanism including thermoregulation. Consequently, a reduced afferent input to the thermoregulatory center might lead to a reduction in sweating capacity below the lesion level. This could increase exercise-induced heat strain. The aim of our study was to assess and compare the thermoregulatory responses of athletes with a spinal cord injury during real wheelchair basketball and rugby games.

**METHODS:**

Ten male national league wheelchair rugby players (WRP) with tetraplegia (mean  $\pm$  SD, age  $37.1 \pm 7.4$  y; body mass:  $76.6 \pm 11.3$  kg) and 5 male Swiss wheelchair basketball national team members (WBP) with a paraplegia (age  $36.5 \pm 7.4$  y; body mass:  $80.8 \pm 10.5$  kg) participated on different days in two competitive Swiss league rugby games and in one wheelchair basketball game respectively. The duration of each rugby game was 4 x 8 minutes (effective) and the conditions were  $23.1 \pm 1.3$  °C,  $41.8 \pm 2.2$  % rh. For the basketball game, the duration was 4 x 10 minutes (effective) and the condition was  $30.3$  °C,  $47.1$  % rh. Core temperature (Tc) was constantly monitored during the games by using an intestinal telemetric pill. Maximal (Tcmax) and the difference between baseline and end core temperature (Tcup) were calculated afterwards. Fluid loss was calculated (FL) by including pre-/post-weight and drinking volume. Rated perceived exertion (RPE) and thermal sensation (TS) were recorded before and immediately after the game.

**RESULTS:**

Tcup significantly increased in WRP in both games (game 1:  $0.89 \pm 0.48$  °C,  $p < 0.001$ , game 2:  $0.79 \pm 0.14$  °C,  $p < 0.001$ ). For the WBP there was also a significant increase in Tcup ( $0.73 \pm 0.23$  °C,  $p = 0.003$ ). Comparing both groups there were no significant differences between WRP and WBP in Tcup and Tcmax. WBP ( $1538.6 \pm 643.3$  g) showed a significantly higher FL in their game compared to both rugby games (game 1:  $383.9 \pm 217.7$  g,  $p = 0.013$ , game 2:  $313.27 \pm 235.55$  g,  $p = 0.011$ ). TS was in both rugby games significantly lower (game 1:  $1.9 \pm 1.1$   $p = 0.04$ , game 2:  $1.7 \pm 1.10$ ,  $p = 0.02$ ) compared with the basketball game ( $3.0 \pm 0.7$ ).

**CONCLUSION:**

During real competitive wheelchair games, the Tc for both, WRP and WBP increased significantly with no significant difference between the groups. It is interesting that WRP had a lower playing-time and played in considerably cooler conditions, but still reached similar values in Tc. This could be due to the higher lesion level and therefore the greater impairment of vaso- and sudomotor functions. The higher FL in WBP could be explained by the lower impairment or as well to the hot ambient temperature. The hot conditions in the sports hall during the basketball game might be the reason for the high TS in this players compared to WRP.

### INFRARED THERMOGRAPHY IN RUNNING AND CYCLING EXERCISE TESTING

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#### INTRODUCTION:

Diagnostic methods to measure acute and chronic physiological adaptations to exercise are mostly invasive (blood analysis, biopsy) or not contactless (near-infrared spectroscopy, electrocardiogram, breath analysis, etc.). Contactless and non-invasive Infrared Thermography (IRT) has the potential to measure acute neural, cardiovascular, and thermoregulatory adjustments during exercise in humans [1]. The purpose of this observational study is whether IRT can measure increasing load and differentiate between running and cycling due to detectable variations of the surface radiation temperature (T<sub>sr</sub>) during step-wise incremental exercise testing (XT). Therefore, we observed the T<sub>sr</sub> changes of the calves with respect to relevant stages of an XT. Moreover, we were the first to investigate whether there is a difference of the T<sub>sr</sub> variations between running and cycling XT within individuals.

#### METHODS:

10 healthy and active men (age: 23 years (SD: 2); VO<sub>2</sub>max: 53.3 ml/min/kg (SD: 5.02)) had to perform a treadmill XT in the first week and a cycle ergometer XT in the following week. Blood lactate samples were taken from the earlobe and individual anaerobic threshold was determined. A high-resolution thermocamera was applied for the measurement of T<sub>sr</sub>. The thermocamera focus was directed to the back-side of the calves. T<sub>sr</sub> data were analyzed at resting conditions (PreXT), maximal exhaustion (PostXT), and after a three minute recovery period (Rec). We also calculated T<sub>sr</sub> at individual anaerobic threshold by linear interpolation (IAT) and conducted a two-factorial, repeated-measures ANOVA.

#### RESULTS:

We detected a progressive decrease of T<sub>sr</sub> (°C) until voluntary exhaustion during both XT types ( $\Delta$ PreXT-IAT: -1.54°C (SD: 0.71);  $\Delta$ IAT-PostXT: -0.6°C (SD: 0.78)) and an immediate increase of T<sub>sr</sub> from PostXT to Recovery ( $\Delta$ Post-Rec: +1.7°C (SD: 0.75)). There is a highly significant difference of T<sub>sr</sub> between all relevant stages for both XT types ( $p < .001$ ) with a large effect (partial Eta squared = 0.84) and a significant difference of the T<sub>sr</sub> variation between running and cycling XT within individuals ( $p = 0.048$ ) with a large effect (partial Eta squared = 0.2)

#### CONCLUSION:

The decrease of T<sub>sr</sub> can be attributed to the sympathetic response to an increasing exercise intensity, which causes vasoconstriction of skin blood vessels. The increase of T<sub>sr</sub> at the end of XT can be related to the vasodilation of perforator vessels in the subcutaneous tissue due to an increase of the core body temperature and the cessation of muscle activation. The T<sub>sr</sub> differences between the XT types could be related to the amount of involved muscle mass. The combined consideration of these physiologically plausible results with the practicability of the IRT application during dynamic exercises leads to the assumption that infrared thermography is a promising tool for individual performance diagnostics.

[1] Hillen et al. (2020) Infrared Thermography in Exercise Physiology: The Dawning of Exercise Radiomics. Sports Med. 50(2):263-282.

## OP-PN02 Cardiovascular physiology

### CENTRAL AND PERIPHERAL CIRCULATION AT EXERCISE ONSET: THE ROLE OF CENTRAL COMMAND

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#### INTRODUCTION:

The control of peripheral circulation during exercise is a complicated and multifaceted phenomenon involving neural (central command and sympathetic nerve activity) and peripheral aspects (nitric oxide, temperature and pH). Though the involvement of central command in the regulation of central hemodynamics at the onset of exercise is relatively well known, its contribution to peripheral hemodynamics is still debated. Therefore, the purpose of the present study was to investigate central and peripheral hemodynamics during low intensity electrically-evoked muscle contractions (bypassing central command) in comparison to voluntary muscle contractions (with central command).

#### METHODS:

Cyclic quadriceps isometric contractions (1 every second), either electrically-evoked (ES; trains of 20 square waves of 1 ms) or performed voluntarily (VC), were executed by 10 healthy males (26±3 years). In both trials, matched for force output, peripheral (femoral blood flow, BF) and central (heart rate, HR; stroke volume, SV, cardiac output, CO) hemodynamics were analyzed.

#### RESULTS:

The baseline values, as well as total work and oxygen uptake during both trials were alike. At the onset of exercise, both ES and VC exhibited similar BF hyperemia (ES: 611 ± 144 vs. VC: 665 ± 165 ml/min), and peaks of HR (69 ± 4 vs. 73 ± 6 bpm) and CO (7.1 ± 0.5 vs. 7.3 ± 0.7 L/min, all  $P > 0.05$ ), respectively. After ~50 seconds, all the variables drifted to lower values. Collectively, the hemodynamic showed equal responses.

#### CONCLUSION:

These results suggest a similar pathway for the initial increase in hemodynamic in both conditions, likely involving similar vasoactive factors and feedbacks from contracting muscle. On the contrary, the parallel responses despite the different approaches, suggest an exiguous role of central command on peripheral and central circulation during the onset of low intensity quadriceps contractions.

### DECREASE IN WORK RATE IN ORDER TO KEEP A CONSTANT HEART RATE: EFFECTS OF A 10-DAY BED REST

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#### INTRODUCTION:

Aerobic exercise prescription, in terms of intensity, is usually set at specific heart rate (HR) values. However, it has been recently demonstrated that during exercise carried out at a HR slightly above that corresponding to the gas exchange threshold (GET), the work rate ( $w$ )

has to decrease in order to maintain HR constant. It is well documented that simulated microgravity (bed rest, BR) determines a significant impairment of skeletal muscle oxidative metabolism, cardiovascular function and exercise tolerance; this led us to hypothesize that the  $\dot{w}$  decrease at a fixed HR could be significantly aggravated by BR. If confirmed, this hypothesis would significantly affect exercise evaluation and prescription in microgravity.

#### METHODS:

Ten young and healthy men (age, 23±5 yr) participated in this study. Subjects were tested before (PRE) and after (POST) a 10-day horizontal BR and performed on a cycle ergometer: a) an incremental exercise up to voluntary exhaustion (INCR); b) a 15-min "HRCLAMPED" exercise, in which  $\dot{w}$  was continuously adjusted to maintain a constant HR, slightly higher than that determined at GET in PRE. During the test, pulmonary O<sub>2</sub> uptake ( $\dot{V}O_2$ ) was assessed breath-by-breath by a metabolic cart. Cardiac output (CO) and stroke volume (SV) were estimated by impedance cardiography. Fractional O<sub>2</sub> extraction changes ( $\Delta[\text{deoxy(Hb+Mb)}]$ ) were evaluated in vastus lateralis muscle by near-infrared spectroscopy (NIRS).

#### RESULTS:

During INCR,  $\dot{w}$  peak (230±41 vs. 251±50 W, P=0.02) and  $\dot{V}O_2$  peak (40.3±6.1 vs. 44.4±7.2 ml·kg<sup>-1</sup>·min<sup>-1</sup>, P<0.001) were significantly lower in POST vs. PRE, whereas HR<sub>peak</sub> remained unchanged (189±6 vs. 187±8 b·min<sup>-1</sup>).  $\Delta[\text{deoxy(Hb+Mb)}]$  peak significantly decreased (p<0.05) in POST compared to PRE.  $\dot{w}$  at GET was not different in POST (113±33 W) vs. PRE (118±33 W). During HRCLAMPED (set at 145±11 b·min<sup>-1</sup>), the decrease in  $\dot{w}$  needed to maintain a constant HR was more pronounced in POST vs. PRE (-39±10 vs. -29±14%) and it was associated with decreases (both in POST and in PRE) of  $\dot{V}O_2$  (-14 and -13%) and  $\Delta[\text{deoxy(Hb+Mb)}]$  (-41 and -18%), whereas SV and CO did not change.

#### CONCLUSION:

During 15-min cycling initially set at a  $\dot{w}$  corresponding to a HR slightly above GET (as frequently done for exercise prescription), in order to keep HR constant,  $\dot{w}$  had to decrease by ~29% and ~39%, respectively, before and after a 10-day bed rest. The  $\dot{w}$  decrease, whose cause(s) still need to be determined, is a sign of exercise intolerance, and was more pronounced compared to that needed to prevent "slow components" of  $\dot{V}O_2$  and muscle fractional O<sub>2</sub> extraction kinetics. Exercise prescription at fixed submaximal HR is problematic, also in microgravity.

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### INFLUENCE OF BLOOD VOLUME ON STROKE VOLUME AND MAXIMUM OXYGEN UPTAKE IN MEN AND WOMEN

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#### INTRODUCTION:

It is well known that maximum oxygen uptake ( $\dot{V}O_{2\text{max}}$ ) is derived from the Fick principle: Stroke volume (SV) x heart rate (HR) x arterio-venous oxygen difference (avDO<sub>2</sub>). Since avDO<sub>2</sub> proved to have only a small impact on alterations in  $\dot{V}O_{2\text{max}}$  and maximum heart rate only slightly differs between trained and untrained athletes, increases in  $\dot{V}O_2$  result primarily from an increase in SV. Studies have shown that the SV response during exercise generally depends on an individual's blood volume (BV); to this day, however, the exact relationship between SV and BV has not been determined. For this purpose, not only resting BV, but also its changes during exercise have to be considered. Therefore, the aim of this study was to investigate the influence of BV on SV and thereby  $\dot{V}O_{2\text{max}}$  during submaximal and maximal exercise in differently trained men and women.

#### METHODS:

Aerobic performance was determined in 50 healthy, non-smoking subjects (age: 27.3±5.3yrs, height: 175±10cm, body mass: 69.0±11.4kg) during an incremental cycle ergometer test. Simultaneously, cardiac output (Q) was measured using inert gas-rebreathing in men (n=24, Innocor) and impedance cardiography in women (n=26, PhysioFlow Enduro). The optimized CO-rebreathing method was used to determine Hbmass and BV. BV during exercise was calculated according to the following formula: Hbmass(g) x 100 / ([Hb](g/dl-1) x 0.91). Additionally, a 3-dimensional echocardiography was performed to calculate heart volume.

#### RESULTS:

$\dot{V}O_{2\text{max}}$  ranged between 47.5 and 74ml·kg<sup>-1</sup>·min<sup>-1</sup> in males and 31.8 and 61.7ml·kg<sup>-1</sup>·min<sup>-1</sup> in females. Hbmass was between 746g and 1365g and 389g and 843g, respectively. Mean SV increased significantly in both groups from resting to submaximal conditions (60%  $\dot{V}O_{2\text{max}}$ ; men: +56±20ml, women: +52±23ml) with no further increase until exhaustion. Mean BV significantly decreased from resting to submaximal conditions and in the further course until exhaustion (-540±172ml; -280±113ml). Linear regression analysis showed a moderate correlation between SV and BV in males (r=.66, p<.001) and females (r=.51, p=.01), while  $\dot{V}O_{2\text{max}}$  was strongly correlated to BV<sub>max</sub> (r=.69, p<.001; r=.85, p<.001) and Hbmass (r=.67, p<.001; r=.84, p<.001). In both groups, heart volume was significantly correlated to resting BV (r=.73, p<.001; r=.70, p<.001). The slopes of the regression lines showed a change in BV of 1000ml was associated with a change in SV<sub>max</sub> of 22.2ml in men and 13.3ml in women, an increase in Q<sub>max</sub> by 3.4L and 2.9L and in  $\dot{V}O_{2\text{max}}$  by 384ml/min<sup>-1</sup> and 624ml/min<sup>-1</sup> respectively.

#### CONCLUSION:

Our results clearly demonstrate the strong influence of BV on the SV response during exercise and therefore  $\dot{V}O_{2\text{max}}$  in differently trained men and women. Hereby, increases in SV can be largely ascribed to greater left-ventricular filling as a result of increased venous return. As we found large inter-individual variability among subjects, other parameters affecting SV such as contractility, pre- and afterload need to be considered in future studies.

### TIME-SERIES ANALYSIS OF HEART RATE AND BLOOD PRESSURE DURING STEADY STATE EXERCISE AND RANDOM WORK RATE CHANGES BEFORE AND AFTER BED REST

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#### INTRODUCTION:

Cardiovascular (CV) regulation after changes in work rate (WR) is an important factor to supply the exercising muscles with oxygen. The acute regulations in response to exercise are summarized as 'baroreflex' and 'metaboreflex'.

The present analyses aim at describing the potential changes of cardiovascular regulation during upright exercise before and after bed rest using time series analysis. It was hypothesized, that the interaction of heart rate (HR) and mean arterial blood pressure (mBP), is attenuated after bed rest.

#### METHODS:

20 subjects performed a cycle ergometer exercise test consisting of 5 min rest (REST) 5 min, constant WRs at 30 W (LOW) and 80 W (HIGH) and randomized WR changes (PRBS, average WR 53 W) between these two WRs. This test was performed before (PRE) as well as two and 13 days (R+2, R+13) after 60 days of 6° head down tilt bed rest organized by the European Space Agency. ECG and continuous blood pressure were monitored beat-by-beat for HR and mBP and analysed after 1-s interpolation. Cross correlation functions (CCF) were calculated for WR vs HR and MBP for the PRBS interval and for HR vs. MBP for the PRBS and the last 20 s interval at REST, LOW, and HIGH. Statistical analyses were performed with 2- or 3-way ANOVA and following post- hoc tests (Bonferroni, if appropriate).

**RESULTS:**

The averages of HR and mBP during the steady states and the PRBS were significantly influenced by the WR intensities and the day of examination ( $p < 0.05$ ). Highest differences were observed on R+2 for HIGH in both parameters (+14 bpm, + 13 mmHg). On R+13 still small differences from PRE existed. CCFs showed damped responses of HR to WR and more pronounced responses of mBP to WR (see also Koschate et al. 2018). The HR-mBP CCFs during PRBS are damped compared to the steady states. Damped responses indicated by lower amplitudes in HR-mBP CCFs during exercise at HIGH and PRBS were demonstrated on R+2 and R+13 in all WR conditions.

**CONCLUSION:**

The attempt to analyse HR-mBP by CCF provides a valuable tool to study regulation characteristics. Changes in exercise overlap the direct mBP-HR interactions. Moreover, these data show that bed rest which implies little stimuli to the CV regulation leads to damped responses in HR-mBP. This is in line with orthostatic intolerance after bed rest.

**Reference:**

Koschate J, · L Thieschäfer, · U Drescher, · U Hoffmann (2018): Impact of 60 days of 6° head down tilt bed rest on muscular oxygen uptake and heart rate kinetics: efficacy of a reactive sledge jump countermeasure. *European Journal of Applied Physiology* 118:1885–1901

**AGE-DEPENDENT CARDIAC REMODELING MEASURED BY ECHOCARDIOGRAPHY AFTER CYCLING 3000 KM IN TWO WEEKS.**

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**INTRODUCTION:**

In the athlete's heart, left (LV) and right ventricle (RV) adapt to long-term endurance training by symmetrical increases in size, but the myocardial function remain near-normal at rest. Acute vigorous endurance exercise can induce RV dilatation and reduced function. However, the acute effect of repeated long-term moderate intensity endurance training on ventricular function is unknown, as is whether the cardiac adaptation is similar in young and older athletes. The aim was to investigate if such an intervention was less tolerated at an older age in relation to LV and RV size and function.

**METHODS:**

7 young (Y) ( $30 \pm 2$  y (mean  $\pm$  SD); maximal oxygen uptake ( $\dot{V}O_{2max}$ )  $62 \pm 1$  ml/min/kg) and 7 old (O) men ( $65 \pm 2$  y;  $\dot{V}O_{2max}$   $49 \pm 2$  ml/min/kg) were examined with transthoracic echocardiography (GE Vivid iq) before and after cycling from Copenhagen to Palermo in 2 weeks with a workload of 63 and 65%, respectively, of maximal heart rate for 7-10 hrs/day. Images were obtained at baseline (B) and at arrival in Palermo (P1) and two days later (P2). Standard measurements of LV mass (Cube formula), volumes and biplane ejection fraction (LVEF) was calculated. Global longitudinal strain (GLS) assessed by speckle tracking analysis. Standard measurements of LV diastolic function in early (E) and late diastole (A) and pulsed-wave TDI-derived mitral annular early diastolic velocity:  $e'$ . Standard measurements of RV inflow and outflow size and function measured as fractional area change (FAC). All measurements of size are corrected for body surface area (BSA).

**RESULTS:**

LV of both groups were eccentric remodeled at B. LV was larger in Y compared to O measured as LV mass ( $252 \pm 49$  vs.  $197 \pm 41$  g/m<sup>2</sup>, respectively ( $p < 0.05$ )) and LV end-diastolic volume ( $90 \pm 8$  vs.  $67 \pm 8$  ml/m<sup>2</sup>, respectively ( $p < 0.05$ )), whereas relative wall thickness ( $0.38 \pm 0.04$  vs.  $0.38 \pm 0.08$ , respectively) were similar in Y vs. O. LVEF and GLS ( $56 \pm 5$  vs.  $57 \pm 5\%$  and  $-18 \pm 2$  vs.  $-18 \pm 2\%$ , respectively) were similar at B. LV size and function did not change with cycling in either group.

$E/e'$  was lower in Y vs. O ( $4.2 \pm 1.1$  vs.  $6.3 \pm 1.9$ , respectively ( $p < 0.05$ )) and E/A-ratio higher in Y vs. O ( $1.79 \pm 0.45$  vs.  $1.25 \pm 0.35$ , respectively ( $p < 0.05$ )) and neither changed with cycling.

RV end-diastolic area (RVEDA) ( $12.8 \pm 0.7$  vs.  $10.4 \pm 0.4$  cm<sup>2</sup>/m<sup>2</sup> ( $p < 0.05$ )) were increased in Y vs. O but RV FAC were indifferent. At P1 RV end-systolic area (RVESA) in O increased ( $6.9 \pm 0.5$  vs.  $8.2 \pm 0.5$  cm<sup>2</sup>/m<sup>2</sup> ( $p < 0.05$ )) but remained unchanged in Y. Correspondingly, RV FAC decreased in O ( $34 \pm 4\%$  (B) vs.  $26 \pm 5\%$  (P1) ( $p < 0.05$ )) but was normalized at P2. RV FAC was unchanged in Y at P1 and P2. RV outflow tract (RVOT) was increased in O vs. Y at B ( $18.7 \pm 3.2$  vs.  $16.8 \pm 3.2$  mm/m<sup>2</sup> ( $p < 0.05$ )) and increased in O at P1 ( $19.8 \pm 2.2$  vs.  $17.1 \pm 1.0$  mm/m<sup>2</sup>) ( $p < 0.05$ ).

**CONCLUSION:**

Prolonged moderate intensity endurance training can induce an age-dependent dilatation of RVOT and reversible reduced function of RV but not LV.

**THE EFFECTS OF A 2 DAY CROSS-COUNTRY MOUNTAIN BIKE MARATHON STAGE RACE ON MYOCARDIAL FUNCTION OF AMATEUR MASTER ATHLETES**

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**INTRODUCTION:**

The number of Master Athletes (older than 40) engaging in high intensity training and racing has increased dramatically. Cross-country biking marathons over consecutive days require high power output and intensity. Considering that cardiovascular issues tend to become a greater cause of morbidity and mortality in this age group, we aimed to examine the effect of a 2 day mountain bike marathon on middle aged recreational athletes.

**METHODS:**

19 male master amateur cyclists (aged  $50 \pm 5.8$ ) years registered in a 3 stage marathon race volunteered to participate in the study. 2 months before the race the following were measured: cardiac function at rest (by Echocardiography); complete blood counts and muscle markers for damage;  $\dot{V}O_{2max}$  (by a graded exercise test on a cycle ergometer). During the first 2 days heart rate and GPS data were continuously monitored. Echo measurements and blood samples for inflammation and muscles damage biomarkers were taken approximately

1 hour after the completion of each daily stage. One-way repeated measure analysis of variance was used to find the differences between time points.

**RESULTS:**

Athlete reported an average of  $210 \pm 63.5$  k/week in the 3 months before the marathon. Maximal exercise test showed an average  $\dot{V}O_{2\max}$  of  $50.9 \pm 6.3$  ml/Kg/min, maximal power  $324 \pm 47.6$  W and respiratory anaerobic threshold of 86% of  $\dot{V}O_{2\max}$ . Echocardiography results revealed that 75% and 80% of the participants had higher than normal EDV, ESV respectively. Participants completed the 1st day (94.2K with 1158m elevation) in 5:57 hours and the 2nd day (90.2K with 1204 elevation) in 5:27 hours on average. Average heart rate remained in zone 4 (80-90% of predicted maximal HR) for 32% and 43% of the time during the first and second day respectively. Cardiac and muscle damage biomarkers increase significantly ( $p < 0.0001$ ) during the 2nd day. CPK and CRP levels increased approximately 7 fold (CPK  $153 \pm 79.81$  to  $746.35 \pm 896$ ; CRP from  $1.40 \pm 4.01$  to  $7.10 \pm 5.19$  mg/L) from baseline to the end of the 2nd day. Cardiac specific biomarkers such as troponin T and ProBNP increased significantly ( $p < 0.0001$ ) from  $5.48 \pm 1.78$  to  $31.11 \pm 18.58$  ng/ml and from  $48.43 \pm 28.31$  to  $340.11 \pm 172.98$  pg/ml respectively. Myocardial work estimated by Global work index (GWI) decreased by  $\sim 17\%$  ( $p < 0.0001$ ) on the first day and by 24% on the 2nd day of the race.

**CONCLUSION:**

2 days of physically demanding mountain bike racing caused significant elevations in skeletal and cardiac damage biomarkers in fit master cyclists. The reduction of GWI after the race may imply myocardial fatigue. The clinical significance of these changes requires investigation before any conclusions or recommendations can be made.

**IMPAIRMENT IN BLOOD PRESSURE AND HEART RATE COUPLING DURING SEVERE HYPOKINESIA.**

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**INTRODUCTION:**

Introduction. The transition from supine to head-up position (orthostasis) is accompanied by a change in the activity of regulatory mechanisms that prevent drop in blood pressure (BP). In healthy people with orthostasis, the phase synchronization of BP and heart rate (HR) fluctuations at the frequency of baroreflex waves ( $\sim 0.1$  Hz) is enhanced, which is a manifestation of baroreflex activity/regulation. Violation of the baroreflex (BR) regulation of BP and HR is accompanied by orthostatic hypotension, which can lead to fainting.

Objectives. Using the phase synchronization index (PSI) developed for assessing the coupling of BP and HR fluctuations, the activity of BR was evaluated in volunteers under conditions of 3-week severe hypokinesia (a volunteer stays in an aqueous medium without skin contact with water - dry immersion (DI)).

**METHODS:**

Methods. 10 healthy men (age  $29.3 \pm 3.8$  years; height  $176.4 \pm 3.8$  cm; weight  $71 \pm 10.6$  kg) spent 21 days in DI conditions (Shulzhenko et al., 1976). The subjects performed a passive tilt test (TT) (15 minutes in a supine and 15 min in standing (60 degrees) position) on a day before DI, on the 7th, 14th and 19th days of DI and on the 1st and 5th days of recovery. During the test, BP (Finometer, Netherlands), ECG and respiratory rate (Pneumocard-A, ISS, Russia) were continuously recorded. The algorithm for calculating of PSI was previously described (Negulyaev et al., 2019).

**RESULTS:**

Results. Already on the 7th day of DI, the effect of an increase in the PSI during orthostasis typical for healthy people disappeared. The changes induced by staying in DI persisted throughout the entire exposure period and disappeared on the 5th day after immersion. The changes obtained indicate serious changes in the regulation of BP during simulated microgravity. It should be noted that the absence of changes in PSI in the baroreflex frequency range during orthostasis is characteristic of patients with vasovagal fainting.

**CONCLUSION:**

Conclusion. The lack of amplification of PSI during orthostasis can serve as a diagnostic criterion of orthostatic intolerance resulting from severe hypokinesia.

**References:**

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Shulzhenko, E., Vil-Vilyams, I., Khudyakova, M., and Grigoryev, A. (1976). Deconditioning during prolonged immersion and possible countermeasures. *Life Sci Sp. Res* 14, 289–294.

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**HEMODYNAMICS ADJUSTMENTS AND CARDIOVASCULAR RESPONSE DURING VARIABLE LOAD EXERCISES IN NORMOTENSIVE ADULTS**

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1SCIENCE AND RESEARCH CENTER KOPER, SLOVENIA, 2UNIVERSITY OF SPLIT, FACULTY OF KINESIOLOGY, SPLIT CROATIA, 3UNIVERSITY OF SPLIT, SCHOOL OF MEDICINE, SPLIT, CROATIA; 4MEDICAL UNIVERSITY OF GRAZ, AUSTRIA

**INTRODUCTION:**

The variable load exercise model (e.g., the flywheel, FW) is currently considered to be the most effective method for counteracting muscle atrophy. However, it is still unknown to which extent this type of vigorous exercise actually challenges the cardiovascular system. We investigated the effects of the FW exercise (nHance, Barcelona, Spain) on hemodynamics and cardiovascular adjustments in healthy participants.

**METHODS:**

Thirty participants (age from 20 to 55 y, 37% women) underwent a detailed medical examination and their  $VO_2$  peaks were determined. After the completion of the preliminary sessions, the participants were randomly assigned into three different experimental conditions, that is, the FW squat ergometer set at three different (low at  $0.025$  kg·m<sup>2</sup>, moderate at  $0.050$  kg·m<sup>2</sup> and high at  $0.075$  kg·m<sup>2</sup>) moments of inertia. The hemodynamics response and the heart rate (HR) were continuously monitored (Task force monitor, CNSystems, Graz, Austria) throughout all FW sessions. The blood pressure was assessed via photoplethysmograph using a pneumatic cuff, positioned around the middle finger of the left hand, instructed to be held at the level of the heart throughout the session. The cardio-impedance electrodes were



positioned according to the manufacturer's guidelines to allow non-invasive insight into the hemodynamics throughout the experimental sessions, while the HR was obtained from the bipolar 3-lead electrocardiograph. In parallel, the electromyographic (EMG) activity (TeleMyo 2400T, Noraxon, USA) of the vastus lateralis (VL) muscle was measured throughout the experimental sessions in accordance with the SENIAM guidelines for non-invasive EMG.

**RESULTS:**

A robust rise in mean arterial pressure (MAP) was observed across all three moments of inertia compared to baseline readings ( $p=.001$ ), while MAP head reached the highest values of  $179\pm 4$  mmHg during high inertial loading. All normalized hemodynamics parameters had a similar response to different FW exercise throughout, while the total peripheral vascular resistance increased by 11% and 22% (for both average and maximal readings,  $p=.001$ ) during the high inertial loading. Likewise, an increase in HR was noted during all exercise interventions compared to baseline ( $p=.001$ ), whereas the HR response was 10 bpm higher ( $p=.001$ ) at high level compared to readings at low and moderate inertial loading. There were no correlations observed between relative increase in MAP and the age of the participants for the low, moderate, or high levels of inertial loadings. Finally, no differences were observed for the VL EMG (EMGRMS) activity ( $p=.856$ ) among the three levels of inertial loadings.

**CONCLUSION:**

In conclusion, larger loads of inertia during FW exercise seem to impose a substantial burden to the cardiovascular system, whereas the study population age-related differences did not modulate a robust rise in MAP following FW exercise. Thus, we emphasize caution when attempting to prescribe high-load exercise to counter muscle-atrophy.

The present work was supported by the Slovenian Research Agency (ARRS) under the grant number: Z7-9420, head of project dr. Zubac, D.

**WHOLE BODY PASSIVE HEATING VERSUS DYNAMIC EXERCISE: A VASCULAR BLOOD FLOW PERSPECTIVE.**

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UNIVERSITY OF INNSBRUCK

**INTRODUCTION:**

Passive heating has emerged as a therapeutic intervention for the treatment and prevention of cardiovascular disease. Like exercise, heating increases peripheral artery blood flow and shear rate which may confer favourable vascular endothelial adaptations. However, whilst the application of passive heating interventions are gaining popularity, very few studies have attempted to compare the increase in blood flow and shear rate between whole body passive heating and dynamic lower body exercise. Therefore, the aim of this study was to measure blood flow and shear rate to the non-active (brachial) and active (common femoral artery) skeletal muscle using ultrasound during semi-recumbent stepping exercise matched to the cardiovascular strain measured after whole body passive hot water immersion.

**METHODS:**

In a fixed crossover design, 15 healthy participants (10 male and 5 female,  $25.6 \pm 3.4$  years,  $1.76 \pm 0.1$  m,  $73.6 \pm 9.3$  kg) underwent 30 minutes of whole body passive hot water immersion ( $42^\circ\text{C}$ ) followed on a separate day by 30 minutes of semi recumbent stepping exercise performed at two workloads corresponding to the increase in cardiac output (Qc, inert gas rebreathing) and heart rate (HR, ECG) recorded at the end of passive heating (matched cardiovascular strain).

**RESULTS:**

Dynamic lower body exercise performed at the same matched Qc ( $\Delta 3.32$  Vs  $3.78$  l/min) (22%  $\text{VO}_2$  max) increased common femoral blood flow (1599 ml/min Vs 1947 ml/min) and shear rate ( $162$  s $^{-1}$  Vs  $192$  s $^{-1}$ ) similar to 30 minutes of challenging, but tolerable passive hot water immersion in moderately trained individuals. When exercise intensity was increased to the HR matched intensity ( $\Delta 46$  Vs  $43$  bpm) (45%  $\text{VO}_2$  max), femoral blood flow (1599 ml/min Vs 2588 ml/min) and shear rate ( $161$ s $^{-1}$  Vs  $271$ s $^{-1}$ ) were significantly higher during exercise compared with heating. Passive heating increased brachial artery flow (210 ml/min) and shear ( $265$  s $^{-1}$ ) significantly more than exercise performed at both the Qc (2 ml/min) (8 s $^{-1}$ ) and HR (72 ml/min) (107 s $^{-1}$ ) matched workloads.

**CONCLUSION:**

The findings suggest that whilst whole body heating provides a shear rate stimulus that matches low intensity exercise, it may be far more challenging to endure compared with time matched exercise owing to the greater increase in core temperature ( $1.31$  Vs  $0.39$   $^\circ\text{C}$ ). Furthermore, if higher intensities can be performed, exercise provides a substantially greater shear stimulus toward the active skeletal muscle, which is likely to confer superior vascular adaptations.

**TITLE: SUPRAMAXIMAL INTENSITY EXERCISE TRAINING COMBINED WITH HYPOXIA IMPROVES AORTIC VASORELAXATION**

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**INTRODUCTION:**

Supramaximal intensity repeated sprints training in hypoxia (SupraH) is a novel type of training that is now widely used in sports. It consists in short bouts of all-out sprints interspersed with incomplete recoveries. SupraH induces a compensatory vasodilation in order to restore adequate  $\text{O}_2$  supply to the exercising muscles, that may also have clinical benefits. However, no study has ever investigated its underlying effects on the endothelial and vascular functions.

Therefore the aim of this study was to compare the effects of supramaximal and low exercise intensities in normoxia and hypoxia on vascular reactivity in mice.

**METHODS:**

Adult C57BL/6 male mice underwent treadmill running three times per week, for four weeks at either low (Low: 40min of running at 40% of maximal aerobic speed [ $14.6 \pm 2.2$ cm/s]) or supramaximal intensity (Supra: 4 series of 5x10-s sprints at 150% of maximal aerobic speed [ $59.9 \pm 10.0$ cm/s]) (Lavier et al., 2019). Low and Supra were performed in normoxia (N:  $\text{FiO}_2=0.21$ ) or hypoxia (H:  $\text{FiO}_2=0.13$ ). Aortic vascular reactivity and aortic expression of key proteins involved in NO bioavailability (eNOS, p-eNOS, SOD1, SOD2; SOD3 and p47-phox) were assessed using ex-vivo myograph analysis and western blotting respectively. The end-products of NO, nitrites ( $\text{NO}_2$ ) and nitrates ( $\text{NO}_x$ ), were measured in the plasma using a fluorometric assay.

**RESULTS:**

Vasorelaxation to the endothelium- and NO-dependent vasodilator acetylcholine (ACh) was significantly improved in SupraH compared to SupraN (AUC: 247.6±12.9 vs 206.3±15.1 U; +20%, p<0.05), and in LowH compared to LowN (AUC: 228.9±9.0 vs. 208.0±9.0 U; +10%, p<0.05). The degree of improvement in vasorelaxation was significantly higher in SupraH than in LowH (AUC: 247.6±12.9 vs. 228.9±9.0 U; +8%, p<0.05). Contrary our expectations, there were no differences between the groups for the expression of eNOS, p-eNOS and the ratio of p-eNOS/eNOS. Moreover, no differences were observed between the groups for the expression of any of the anti- nor pro-oxidant proteins studied (SOD1, SOD2; SOD3 and p47-phox). Plasma concentration of NOx and NO<sub>2</sub> did not differ between the groups. Vasorelaxation to the endothelium-independent vasodilator DEA/NO was significantly improved in LowH compared to LowN (AUC: 373.3±10.9 vs. 370.0±8.0 U; +5%, p<0.05), indicating an increased sensitivity of vascular smooth muscle cells to NO and/or an upregulation of guanylyl cyclase activity.

#### CONCLUSION:

This study provides the first experimental evidence that supramaximal exercise intensity in hypoxia improves vascular endothelial function, which was not associated with an increase in expression of aortic proteins or pro- and anti-oxidant proteins.

Lavier, J., Beaumann, M., Ménetrey, S., Mazzolai, L., Peyter, A.-C., Pellegrin, M., and Millet, G.P. (2019). Supramaximal Intensity Hypoxic Exercise and Vascular Function Assessment in Mice. *J Vis Exp*.

### HOLD YOUR BREATH: PERIPHERAL AND CEREBRAL OXYGENATION DURING DRY STATIC APNEA.

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#### INTRODUCTION:

Acute breath-holding deprives the human body from oxygen. In an effort to protect the brain, the diving response is initiated, coupling several physiological responses. The aim of this study was to describe the physiological responses to voluntary breath-holding at the cardiac, peripheral and cerebral level in order to obtain insight into the protective mechanisms for the brain.

#### METHODS:

31 physically active subjects (17 male, 14 female, 23.3 ±1.8 years old) performed a maximal static breath-hold in a seated position. Heart rate (HR) and muscle (M. Vastus Lateralis) and cerebral (prefrontal cortex) oxygenation (by means of near-infrared spectroscopy) were continuously measured. RM MANOVA's were used to identify changes in HR, cerebral (cTOI) and peripheral tissue oxygenation (mTOI) and oxygenated (O<sub>2</sub>Hb) and deoxygenated (HHb) hemoglobin at different time points during apnea.

#### RESULTS:

Subjects held their breath for 157 ±41 s on average (range: 96-244 s). HR started decreasing 15 s after the onset of apnea (p=0.003) reaching minimal values after 83 ±58 s. HR dropped on average by 27 ±14 bpm (30 ±13%) from baseline (p<0.001). mTOI started decreasing 10 s after apnea (p<0.001) and continued to decrease until 10 s post apnea, reaching baseline only 30 s post apnea (p=0.369). mTOI fell on average by 8.6 ±4% (p<0.001). Following an immediate drop after 5 s (p<0.01), cTOI increased continuously, reaching a maximal increase of 4.6 ±3% (p<0.001) after 100 ±49 s, followed by a steady decrease until the end of apnea. cTOI fell on average 6.5 ±7.6% below baseline (p<0.001) with individual decreases up to 25%. cTOI increased immediately after apnea, already reaching baseline 10 s post apnea (p=0.811). One subject fainted during testing after only 65 s of apnea. Visual analysis revealed a similar pattern for HR. Examination of mTOI, mO<sub>2</sub>Hb and mHHb suggested impaired peripheral vasoconstriction, while cTOI showed a very strong immediate drop, followed by incomplete recovery resulting in a second fast drop in cTOI until the subject passed out.

#### CONCLUSION:

During apnea, the human body elicits several protective mechanisms in order to protect itself against the deprivation of oxygen. HR slows down decreasing oxygen demand of the cardiac muscle. The decrease in mTOI and increase in cTOI imply a redistribution of blood flow prioritizing the brain. However, data from one participant suggests that syncope can be induced by impaired redistribution, observed as a less pronounced peripheral vasoconstriction deduced from muscle oxygenation responses and a disturbed cerebral oxygen.

## OP-PN03 Metabolism and Hypoxia

### STRESS RESPONSE DURING A HIMALAYAN TREK: SUB-CLINICAL ETHNIC DIFFERENCES REVEALED BY A MULTI-DOMAIN APPROACH

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#### INTRODUCTION:

Altitude hypoxia is known to act as a physiological stressor. Among other adaptations, HRV and hormonal factors have been stressed [1,2], while mood has been poorly addressed. Beyond the emergence of AMS, the present work aimed to explore sub-clinical adaptations from a multi-domain perspective during a Himalayan trek, comparing two ethnic groups.

#### METHODS:

This work is a subset of "Kanchenjunga Exploration & Physiology" project. 6 healthy Italian trekkers (1 f and 5 m, age 43.83 ± 15.30 years y, BMI = 25.81 ± 3.25 Kg/m<sup>2</sup>) and 6 healthy Nepalese porters (all males, age 30.33 ± 8.55 y, BMI = 24.36 ± 4.70 Kg/m<sup>2</sup>) were recruited. All of them completed ≈ 300 Km distance along a demanding route, covering ≈ 6 hours daily walk, in the Kanchenjunga mountain range, Nepal. None of them suffered from AMS during the trek. All participants underwent: ECG recording, before the trek (Pre), at 3427 m of altitude before the North Base Camp (5143 m of altitude) circuit (bBC), and after that circuit (aBC); blood sample at Pre and after the trek (Post); Italians were required to complete also a mood state questionnaire (58-item POMS) at Pre, at high altitude (4780 m) in the last village prior to the Base Camp (HA), and at Post. From 5 minutes-ECG recording at rest, we evaluated HRV by the mean of time-domain (SDNN and pNN50), frequency-domain (absolute LF and HF power) and non-linear parameters (CSI, CVI and HFD). From blood samples, we evaluated Cortisol (COR) and Prolactin (PRL) concentrations. From POMS questionnaire, we evaluated the Total Mood Disturbance (TMD) score [3].

#### RESULTS:

Linear and non-linear measures of HRV suggested an overall higher parasympathetic tone at bBC, with a following reduction at aBC only in the Italian group. PRL was lower at Post in respect to Pre, but only in the Italian group (p=0.043,  $\mu$ 2p=0.352), whereas no clear trends were found for COR. Mood state of Italians tended to be better (p=0.075,  $\mu$ 2p=0.404) at HA and at post, in respect to Pre.

#### CONCLUSION:

The starting point of an expedition represent per se a stressor and the parasympathetic tone may be higher during the altitude trek; the common stress response in ANS evaluation, i.e. a parasympathetic activity reduction, may therefore emerge after a demanding sojourn in high altitude. We suggest the use of non-linear measures, such as HFD [4], in addition to the most common ones in HRV, to evaluate hypoxia-related adaptations. Volunteers do not undergo to mood disturbances during altitude expeditions, if they are motivated and prepared [5]. Nepalese porters, in respect to Italian trekkers, had minor adaptations, suggesting a less pronounced physiological alteration on the domains hereinto investigated. This novel multi-domain approach to address stress response to hypoxia may open new evidence-based perspectives in the understanding of ethnic advantages to extreme conditions.

References

1. Boos et al. (2017); 2. Richalet et al. (2010); 3. Kenttä et al. (2006); 4. Gomolka et al. (2018); 5. Karinen et al. (2017)

### **“TRAINING-LOW” DURING HEAT ACCLIMATION MITIGATES THE CHANGES IN SUBSTRATE UTILISATION AND PERFORMANCE IN MALE TRIATHLETES.**

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INTRODUCTION:

“Train-low” is a method of carbohydrate (CHO) periodisation intended to reduce muscle glycogen availability during low-intensity (LIT) exercise whilst maintaining adequate CHO for high-intensity exercise, enhancing metabolic adaptations in skeletal muscle. CHO periodisation combined with heat acclimation could provide a novel intervention to improve exercise performance, alleviate heat-associated performance losses and increase endurance training-related adaptation.

METHODS:

Twenty-three male triathletes ( $29 \pm 7$  years,  $VO_{2max} = 62.3 \pm 6.6$  ml/kg/min, maximal aerobic power (MAP) =  $330 \pm 40$  W) were randomly assigned to 3 groups; “train-low” (TL,  $n = 8$ ), “train-low in heat” ( $\sim 37^{\circ}C$ , 50% RH) (TLH,  $n = 8$ ) and control (CON,  $n = 7$ ). All completed a 2-week cycling intervention of 1 h at 60% MAP each morning, with evening high-intensity (HIT) sessions (8 x 5 min at 85% MAP) every other day. Daily CHO intake (6g/kg/day) was consistent for all groups but timed differently throughout the day; where TL and TLH consumed no CHO post evening HIT resulting in low CHO availability for the following LIT. Participants completed a cycling efficiency (CE) test and a 30-min time trial (TT) in both hot ( $\sim 37^{\circ}C$ , 50% RH) and temperate conditions ( $\sim 20^{\circ}C$ , 50% RH) before (pre), immediately (post) and 1-week (post +1) after intervention.

RESULTS:

During the CE test, respiratory exchange ratio at 80% MAP was significantly reduced in TL from pre ( $0.97 \pm 0.06$ ) to post ( $0.94 \pm 0.05$ ) and post +1 ( $0.91 \pm 0.04$ ) ( $P < 0.05$ ). CHO utilisation significantly decreased ( $P < 0.05$ ) for TL from pre ( $4.44 \pm 1.09$  g/min) to post +1 ( $3.25 \pm 0.81$  g/min) and between post ( $3.95 \pm 0.98$  g/min) to post +1. CON significantly reduced CHO utilisation between pre ( $4.27 \pm 0.77$  g/min) and post ( $3.77 \pm 0.62$  g/min). Fat oxidation increased significantly ( $P < 0.05$ ) for TL from pre ( $0.16 \pm 0.35$  g/min) to post +1 ( $0.58 \pm 0.35$  g/min). Mean power during each TT was not significantly different between time points in hot or temperate conditions. Mean heart rate significantly ( $P = 0.01$ ) decreased between pre ( $165 \pm 7$  bpm) and post ( $157 \pm 10$  bpm) in TL during the temperate TT. Coefficient of variation (CV) of LIT mean % MAP reduced between weeks by -0.5% and -1.6% in CON and TLH respectively with no difference in TL (-0.1%). During week 1, TLH % MAP was  $\sim 3\%$  below target during low CHO availability sessions and increased to  $\sim 1\%$  below target during week 2.

CONCLUSION:

“Training-low” during heat acclimation likely blunts the adaptive responses associated with train low through reduced training capacity and/or increased CHO dependence during exercise in the heat. It is currently inadvisable to recommend training with periodised CHO availability during periods of heat acclimation.

### **CHANGES IN ENERGY COST OF RUNNING AFTER A SHORT VS LONG MOUNTAIN ULTRAMARATHON RACE.**

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UNIVERSITÉ JEAN MONNET, SAINT-ETIENNE

INTRODUCTION:

The effect of ultramarathon running on energy cost of running (Cr) is unclear. Studies on changes of Cr during ultramarathons report contradictory results (1). The aim of our study was to examine the effect of completing a mountain ultramarathon of long or short distance on RE during flat and uphill treadmill running.

METHODS:

Seventy-three athletes (27 females,  $37 \pm 8$  y,  $68.9 \pm 11.7$  kg,  $VO_{2max} = 58.3 \pm 10.8$  ml/kg/min) participating in different races of the Ultra-Trail du Mont-Blanc, ranging from 40 km and  $\pm 2,300$  m of elevation to 170 km and  $\pm 10,000$  m were recruited. All athletes visited our laboratory 5-8 weeks before the event, for a familiarisation visit and an incremental test. 24-48 h before the race, as well as within 2 h of finishing the race, the subjects ran for 4 min on a flat treadmill at 90% of their maximal speed on the previous test (FLAT) as well as at 70% of their maximal speed at 15% incline (UH). Ventilation,  $VO_2$  and RER were measured using a portable open-circuit breath-by-breath metabolic cart and used to calculate Cr. As some of the subjects were not able to complete the 4-minute stage after the event, data were analysed between 2:30-3:00 of each test, after ensuring that the subjects had achieved steady state. The subjects were split according to race distance in two groups: LONG ( $> 100$  km) and SHORT ( $< 100$  km). The effect of race distance on change in Cr was evaluated using a 2-way ANOVA. Due to the changes in ventilation, Cr was also analyzed removing the work of breathing (Cr-breath).

RESULTS:

Forty-six athletes completed the races and run on the treadmill during at least 3 minutes after the event. In FLAT, Cr increased by  $9.4 \pm 9.4\%$  ( $p=0.002$ ) after SHORT, and this increase was significantly higher ( $p=0.033$ ) than after LONG ( $3.0 \pm 11.1\%$ ). Ventilation was  $18.6 \pm 16.3\%$  higher ( $p<0.001$ ) in pre- vs post-race, independently of the distance, and RER was  $11.6 \pm 4.6\%$  lower post-race ( $p<0.001$ ), with no differences between distances. When eliminating the cost of breathing, the difference between SHORT and LONG was higher ( $8.9 \pm 8.2\%$  vs.  $2.2 \pm 11.0\%$ , respectively). In UH, Cr did not change after LONG; but it was significantly higher after SHORT ( $6.4 \pm 7.7\%$ ,  $p=0.03$ ). Ventilation was  $18.8 \pm 15.7\%$  higher with no effect of distance ( $p<0.001$ ), and RER decreased for SHORT and LONG ( $-10.5 \pm 3.1\%$  vs.  $-7.4 \pm 4.7\%$ ,  $p<0.001$ ), the change being significantly higher in SHORT ( $p=0.003$ ). After eliminating the cost of breathing, the change in Cr-breath was still significant for SHORT ( $+ 5.5 \pm 7.5\%$ ,  $p=0.003$ ) but not for LONG ( $+ 0.1 \pm 7.5\%$ ).

**CONCLUSION:**

It appears that running a short distance mountain ultramarathon has a greater negative impact in Cr compared to running a long mountain ultramarathon, in both FLAT and UH conditions. This could be caused by the greater intensity of the SHORT events, leading to greater muscle fatigue. The calculated Cr without the cost of breathing led to magnified differences between SHORT and LONG.

(1) Vernillo et al. (2018). *Front. Physiol*, 8:783

### **ENHANCED SKELETAL MUSCLE OXIDATIVE CAPACITY FOLLOWING MODERATELY INCREASED TESTOSTERONE CONCENTRATION ON YOUNG HEALTHY WOMEN**

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**INTRODUCTION:**

Testosterone has been reported to increase mitochondrial biogenesis specifically in skeletal muscle of mice (1). We recently showed that endurance performance is enhanced by a moderate increase of testosterone concentration for 10 weeks compared to placebo in young healthy women (2). Here, the aim was to examine if any adaptations induced by testosterone on skeletal muscle and blood compartment volumes may account for the observed improvement in performance.

**METHODS:**

In a double-blind randomized, placebo-controlled trial forty-eight healthy active women (age 28.0±3.7 years; height 168.7±5.5 cm; body mass 66.8±7.2 kg) were randomized to 10 weeks of either 10 mg of testosterone cream daily or placebo. A skeletal muscle biopsy was collected before and after the intervention. Specific mitochondrial respiratory flux was measured in isolated mitochondria by high-resolution respirometry. Capillary density, and capillary number per fiber by immunohistochemistry. Mitochondrial proteins abundance by immunoblot analysis and blood compartment volumes by carbon monoxide rebreathing technique. One-way analysis of variance was used to assess the between group differences for the normal distributed data.

**RESULTS:**

Specific mitochondrial respiratory flux activating complex I ( $p<0.05$ ), linked complex I and II ( $p<0.05$ ), uncoupled respiration ( $p<0.05$ ) and electron transport system capacity ( $p<0.05$ ) were significantly higher following testosterone administration compared to placebo. None of these changes were significantly correlated to change in endurance performance. Leak respiration and fat respiration did not change following the intervention. Several mitochondrial proteins level (citrate synthase, complex I, II, III, IV-subunit 2, IV-subunit 4, V), capillary density, capillary per fibers, and assessed hematological parameters (blood volume, plasma volume, hemoglobin mass, red blood cells volume) were unchanged by the intervention and between groups.

**CONCLUSION:**

Here we show that mitochondrial oxidative capacity was enhanced by a moderate increase in testosterone concentration in young healthy women compared to placebo. However, our previously reported increase in endurance performance as an effect of testosterone cannot be explained by any alterations in oxygen carrying- and diffusion capacity or by changes in electron transport chain protein content.

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### **EFFECT OF REPEATED SPRINT EXERCISE WITH POST-EXERCISE BLOOD FLOW RESTRICTION ON MUSCLE OXYGENATION**

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**INTRODUCTION:**

Repeated sprint training increases maximal oxygen uptake and muscle buffer capacity following several weeks of training. Although several factors are suggested to be involved in improved muscle buffer capacity, the accumulation of metabolites (e.g., lactate, proton) in working muscle would be an important stimulus. Blood flow restriction during low intensity exercise is known to augment metabolites accumulation in working muscles. However, the use of blood flow restriction during repeated sprint exercise is not practical due to increased muscle pump action and venous return during the exercise. The purpose of the present study was to determine the effect of repeated sprint exercise and post-exercise blood flow restriction (blood flow restriction during rest periods between sprints) on muscle oxygenation in working muscles.

**METHODS:**

Eight health males (22.5 ± 0.2 years, 173.1 ± 2.3 cm, 65.8 ± 2.5 kg) performed two different trials on different days: either repeated sprint exercise with blood flow restriction during rest periods between sets (BFR trial) or without blood flow restriction (CON trial). A repeated sprint exercise consisted of three sets of 3×6-s maximal sprints (pedaling) with 24s rest periods between sprints and 5 min rest periods between sets. In BFR trial, blood flow restriction (100-120mmHg) for both legs was conducted two min of between sets. During the exercise, power output, muscle oxygenation for the vastus lateralis muscle (using near-infrared spectroscopy), arterial oxygen saturation (SpO<sub>2</sub>) and HR were evaluated. Venous blood samples were obtained before exercise, during rest periods between sets and after exercise.

**RESULTS:**

During blood flow restriction between sets, BFR trial presented significantly higher deoxygenated hemoglobin (deoxy-Hb) ( $P = 0.003$ ) and lower tissue saturation index (TSI) in working muscles ( $P = 0.001$ ) than those in CON trial, while SpO<sub>2</sub> did not differ significantly between the two trials ( $P = 0.88$ ). In contrast, no significant difference between the two trials was observed for either deoxy-Hb ( $P = 0.94$ ) or TSI ( $P = 0.32$ ) during 6s maximal sprint. Moreover, power output each sprint throughout nine sprints did not differ significantly between the two trials ( $P = 0.20$ ). Exercise-induced changes in blood lactate ( $P = 0.09$ ) or blood pH ( $P = 0.86$ ) were not significantly different between the trials.

**CONCLUSION:**

Repeated sprint exercise with post-exercise blood flow restriction facilitated increase in deoxy-Hb and decrease in TSI. Therefore, post-exercise blood flow restriction during repeated sprint exercise augmented deoxygenation of hemoglobin and local hypoxia in working muscles compared with the same exercise without post-exercise blood flow restriction.

#### **PHYSIOLOGICAL AND BEHAVIOURAL RESPONSES TO PROLONGED ENDURANCE EXERCISE**

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##### **INTRODUCTION:**

Very prolonged exercise (e.g. 100 h) uncouples perceived exertion from workload and alters substrate utilisation towards greater fat oxidation. Such shifts have been associated with sustainable pace selection via inter-related behavioural and physiological processes. However, it is unknown if these shifts occur after shorter periods of prolonged exercise (e.g. a day's activity). Thus, we assessed whether 7 h of sustained exercise would uncouple perceived exertion from workload and induce a metabolic shift towards greater fat oxidation, as previously observed from much longer exercise (100 h).

##### **METHODS:**

Eleven participants (6 female; age  $29 \pm 7$  years;  $VO_{2peak}$ :  $43 \pm 6$  mL/kg/min), grouped by fitness (4 pairs, 1 trio), completed ~7 h of prolonged exercise (walk/run) that comprised of a 6.5-km loop course on wilderness terrain near the Raymond Priestley Centre, University of Birmingham, Coniston, UK. During the prolonged bout, heart rate (HR) was continuously recorded, spot blood glucose samples were obtained in the first and final hour ( $n=5$ ), and three participants completed two laps (first and final hour) wearing a portable metabolic system (K5, Cosmed). Before and within 1 h of finishing, participants completed a standardised exercise stress test (rest, cycling at low (75 W) and moderate intensity (120/150 W), and arm cranking (25 W; all 10-min bouts), wherein ratings of perceived exertion (RPE), continuous HR, and breath-by-breath respiratory gases (cycling only) were recorded. Resting and low-intensity exercise (75 W-cycling and arm cranking) blood glucose was measured via a finger prick sample. Substrate utilisation was determined from respiratory gas analysis

##### **RESULTS:**

Participants completed  $37 \pm 6$  km over a range of 6.5-8.5 h of sustained exercise, with HR averaging  $66 \pm 9\%$  of HR range. Blood glucose decreased across the bout ( $5.4 \pm 1.5$  vs.  $4.3 \pm 0.7$  mmol/L, first vs. final hour,  $p=0.08$ ). In response to the standardised exercise test, post-prolonged exercise RPE was higher during both low and moderate intensity cycling ( $8 \pm 1$  vs.  $10 \pm 1$  and  $12 \pm 1$  vs.  $14 \pm 2$ , respectively;  $p<0.01$ ), as was HR ( $115 \pm 14$  vs.  $124 \pm 14$  bpm and  $147 \pm 19$  vs.  $156 \pm 17$  bpm;  $p<0.01$ ). For arm cranking, RPE was similar ( $10 \pm 2$  vs.  $11 \pm 5$ ;  $p=0.65$ ) even though HR was elevated ( $106 \pm 14$  vs.  $115 \pm 11$  bpm;  $p<0.01$ ) following prolonged exercise. Respiratory exchange ratios at rest and during standardised cycling were reduced following prolonged exercise (rest:  $0.82 \pm 0.06$  vs.  $0.72 \pm 0.07$ , 75 W:  $0.88 \pm 0.03$  vs.  $0.79 \pm 0.04$ , 120/150 W:  $0.92 \pm 0.03$  vs.  $0.86 \pm 0.05$ ; all  $p<0.01$ ). Blood glucose was reduced at rest and during low intensity standardised exercise (rest:  $4.21 \pm 0.39$  vs.  $3.50 \pm 0.70$  mmol/L, 75 W:  $4.16 \pm 0.70$  vs.  $3.16 \pm 0.51$  mmol/L, arm:  $4.16 \pm 0.70$  vs.  $3.16 \pm 0.51$  mmol/L; all  $p<0.01$ ).

##### **CONCLUSION:**

These data indicate that ~7 h of sustained exercise does uncouple workload and perceived exertion, and shifts substrate utilisation towards greater fat metabolism.

#### **REST AND MAXIMAL FAT OXIDATION: INDEPENDENT AND COMBINED ROLE OF BODY COMPOSITION, CARDIORESPIRATORY FITNESS AND STRENGTH IN ADULTS.**

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##### **INTRODUCTION:**

Fat oxidation capacity might be modulated positively with physical fitness improvements, which is related to health benefits. However, it remains unclear what physical fitness components (Body Composition (BC), Cardiorespiratory fitness (CRF) or Muscular Strength (MS)) have a higher influence on fat oxidation capacity at rest (RFO) and during exercise (MFO). The aim of this study was to analyse the independent and combined effect of BC, CRF and MS on RFO and MFO.

##### **METHODS:**

One hundred adults (66 males; age  $24.8 \pm 7.9$ y) were included. Gas exchange was recorded for 30min at rest for RFO. An incremental exercise protocol in cycle ergometer with two consecutive phases was performed for MFO and  $VO_{2max}$  using indirect calorimetry. The first phase aimed to determine MFO, it consisted of 3 min steps of 15/30W (depending on weight status) increments with a cadence of 60-80rpm. The test was stopped when  $RQ \geq 1$ . After 3-5 min rest, the second phase to detect  $VO_{2max}$  began with steps of 1 min and the same incremental load until exhaustion. Bioimpedance analysis was used to assess BC (body fat index (BFI) and fat-free mass index (FFMI)). MS was assessed by handgrip dynamometry (HG) and the standing long jump test (LJ). A strength cluster (SC) was made with HG and LG. T-test was used to assess differences between males and females ( $p<0.05$ ). Linear regression analyses were performed between RFO and MFO with BC, CRF, MS variables. To test the combined influences of CRF with BC and MS on RFO and MFO, groups of high/low were created using p50 of normative values adjusted by sex. The differences were assessed by ANOVA ( $p<0.05$ ).

##### **RESULTS:**

Males have higher CRF, FFMI, MS and females have higher BFI, RFO/FFM and MFO/FFM ( $p<0.05$ ). CRF and HG levels were correlated with RFO ( $r=0.255$   $p=0.01$  and  $r=0.253$   $p=0.027$ ; respectively). Likewise, BFI, CRF and SC were correlated with MFO ( $r=0.311$   $p=0.002$ ;  $r=0.59$   $p<0.001$  and  $r=0.280$   $p=0.015$ ; respectively). The best regression model for the prediction of RFO included BFI and CRF ( $r^2=0.107$ ) and for MFO, Sex(men) and CRF ( $r^2=0.487$ ). Differences in RFO/FFM, MFO and MFO/FFM were observed between groups combining low and high CRF/BFI and CRF/FFMI, in which high CRF groups presented higher fat oxidation rates regardless of their body composition status. Similarly, there were differences in MFO/FFM between combined groups of HighCRF with Low or High HG.

##### **CONCLUSION:**

MFO is mainly affected by CRF and MS and to a lesser extent by FFMI and BFI. RFO is poorly influenced by physical fitness. Optimal strategies for increasing fat oxidation rates should include exercise intervention in order to increase CRF and MS jointly.

**MAXIMAL FAT OXIDATION CAPACITY PREDICTS CARDIOMETABOLIC RISK FACTORS IN HEALTHY YOUNG ADULTS**

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**INTRODUCTION:**

Association between cardiorespiratory fitness (VO<sub>2</sub>max) and cardiometabolic risk (CMR) has been shown previously; however it is unknown the association of resting fat oxidation (RFO), maximal fat oxidation (MFO) and FatMax (intensity at which MFO is reached) with CMR. Thus, the aim of this study was to examine the association between RFO, MFO and FatMax with CMR.

**METHODS:**

Eighty-one healthy adults (31 women; 22.72 ± 4.40 years) participated in this cross-sectional study. Glucose, triglycerides and inflammatory biomarkers (TNF $\alpha$  and IL-6) were analyzed in plasma. A CMR index was computed from the sex- and age-standardized values of the aforementioned individual risk factors (waist circumference, body fat percentage, systolic blood pressure, diastolic blood pressure, plasma glucose and triglycerides). RFO and MFO were determined through indirect calorimetry. Maximal oxygen uptake (VO<sub>2</sub>max) test was performed until exhaustion after MFO test. MFO and VO<sub>2</sub>max were relativized by lean mass of legs/height<sup>2</sup> to avoid body surface effect. Different groups were categorized in high and low level by dividing the variables in tertiles and grouping them into low (tertile 1) and high level (tertiles 2 and 3). To verify the extent to which MFO and VO<sub>2</sub>max predict the CMR, different linear regression models were fitted; unadjusted (model 1), and adjusted by sex (model 2), age (model 3) and VO<sub>2</sub>max or MFO relativized by lean mass of legs / height<sup>2</sup> (model 4). A one-way ANOVA was performed to determine differences between groups (Sex, tertiles of MFO and VO<sub>2</sub>max) with significance at  $p < 0.05$ .

**RESULTS:**

RFO was not associated with any of the individual or clustered CMR factors ( $p < 0.05$ ). FatMax, MFO and VO<sub>2</sub>max were predictors of individual CMR factors as waist circumference ( $R^2 = 0.144$ ;  $R^2 = 0.241$ ;  $R^2 = 0.285$ ;  $p = 0.001$ ; respectively) and triglycerides ( $R^2 = 0.111$ ;  $p = 0.004$  and  $R^2 = 0.130$ ;  $p = 0.002$  and  $R^2 = 0.093$ ;  $p = 0.008$ ; respectively), and clustered CMR factors ( $R^2 = 0.105$ ;  $p = 0.008$  and  $R^2 = 0.162$ ;  $p = 0.001$  and  $R^2 = 0.239$ ;  $p = 0.001$ ; respectively). VO<sub>2</sub>max was also associated with body fat percentage ( $R^2 = 0.105$ ;  $p = 0.003$ ) and diastolic blood pressure ( $R^2 = 0.083$ ;  $p = 0.01$ ). Associations were maintained after adjusting for sex or age ( $p < 0.05$ ). The group with the highest level of MFO or VO<sub>2</sub>max obtained lower CMR ( $p = 0.001$  for both); even adjusting for sex or age ( $p < 0.01$ ). TNF $\alpha$  and IL-6 were not associated with any dependent variable (RFO, MFO or VO<sub>2</sub>max).

**CONCLUSION:**

FatMax and MFO are good predictors of CMR, regardless of age and sex. Nonetheless, these associations seem to be explained by VO<sub>2</sub>max, which showed the highest association with CMR regardless of FatMax and MFO. The current results should be considered by practitioners, who may conduct a MFO test in order to avoid a maximal effort in people at risk of cardiovascular events.

**EFFECT OF A NOVEL LIVE HIGH, TRAIN LOW HYPOXIA PROTOCOL ON ERYTHROPOIESIS AND HAEMOGLOBIN MASS IN WELL-TRAINED RUNNERS**

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**INTRODUCTION:**

The hypoxic dose necessary to elicit an increase in haemoglobin mass (Hbmass) which translates into improved endurance performance remains equivocal. In 2016 a hypoxic dose metric, termed “kilometer hours”, was proposed as follows:  $\text{km}\cdot\text{h} = (\text{m}/1000) \times \text{h}$ , where m denotes equivalent altitude in meters and h is total duration of exposure in hours (1). We examined the effect of a novel, mixed altitude LHTL protocol, predicted to increase Hbmass by ~3-4% (1) in trained runners.

**METHODS:**

10 male runners (26.5±4.8 yr; 66.4±4.2 kg), completed two 14 d training camps in a single-blinded, counterbalanced, crossover design. The intervention (LHTL) consisted of 6 hr.d-1 during the day, and 10 hr.d-1 overnight of normobaric hypoxia in an “altitude dormitory”. Daylight hypoxia magnitude increased from 3000 m to 5500 m and the overnight dose increased from 2400 m to 3000 m equivalent altitude. The total hypoxic dose in “kilometre hours” was ~792 km.h. For control (CON) subjects remained within the dormitories in normoxia. Training was conducted at sea level. Haematological markers and Hbmass were taken before (B0), during (D1, D4, D7) and post (P1, P7, P14). Lactate threshold (LT2) and VO<sub>2</sub>max were measured at B0 and P1. A 2-way ANOVA (condition x day) was used for statistical analysis.

**RESULTS:**

A condition x day interaction occurred for EPO ( $P = 0.02$ ) and sTfr ( $P < 0.001$ ). EPO showed a significant off-response in LHTL, decreasing at P7 (11.3±4.2 mIU.ml-1;  $P = 0.008$ ) and P14 (10.8±4.1 mIU.ml-1;  $P = 0.01$ ) compared to D1 (17.5±6.5 mIU.ml-1), whereas an increase in sTfr was observed at D14 (3.6±0.7 mg.L-1;  $P = 0.007$ ) compared to B0 (2.9±0.6 mg.L-1). An interaction was also found for Ret% ( $P < 0.001$ ) and [Hb] ( $P < 0.001$ ). Ret% was higher in LHTL at D4 (1.2±0.2%;  $P = 0.01$ ) and D7 (1.4±0.3%;  $P < 0.001$ ) compared to B0 (1.0±0.2%) and [Hb] was higher at P1 (15.7±9.2 g.dL-1;  $P = 0.002$ ) compared to B0 (14.8±11.4 g.dL-1). There was no interaction for Hbmass ( $P = 0.96$ ), however a main effect of day occurred ( $P < 0.001$ ) where Hbmass at P7 (877±10 mL) was greater than D1 (861±10 mL;  $P = 0.048$ ). There was no change from B0 to P1 in VO<sub>2</sub>max in CON (67.3±4.5 vs. 66.5±3.9 ml.kg-1.min-1;  $P = 0.60$ ) or LHTL (68.1±4.1 vs. 64.8±4.7 ml.kg-1.min-1;  $P = 0.08$ ). Similarly, no change in LT2 from B0 to P1 was evident for CON (17.5±0.8 vs. 17.7±0.6 ml.kg-1.min-1;  $P = 0.10$ ) or LHTL (17.9±0.7 vs. 17.7±0.8 ml.kg-1.min-1;  $P = 0.80$ ).

**CONCLUSION:**

The present data reveal evidence of erythropoiesis in response to the LHTL intervention, however this did not translate into elevated Hbmass, VO<sub>2</sub>max or LT2. We conclude the dose-response relationship between “kilometer hours” and Hbmass is not valid for trained runners when exposed to a greater hypoxic magnitude for shorter duration, as compared to conventional altitude training camps lasting 3-4 wk.

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### BIOCHEMICAL RESPONSES IN A BRAZILIAN ENDURANCE TRIATHLON RACE

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#### INTRODUCTION:

Triathlon is one of the most flourishing sports in the world. The great challenge in triathlon is to integrate three distinct modalities that differ from the others in duration, exercise mode, limbs movement patterns and main muscular groups[1, 2]. And the success in triathlon has been related to a specific performance of each sport (swimming, cycling and running) and its technical and/or tactical approaches during the race[3]. Accordingly, the aim of this study was to analyze the acute effect of endurance triathlon race on biochemical variables in amateur trained athletes.

#### METHODS:

Quasi-experimental research with 08 male volunteers; amateur athletes trained in triathlon. The participants signed an informed consent document to participate in research involving human subjects in accordance to the Declaration of Helsinki[4]. The data collection was a realized during the Triathlon Endurance 2017 race of UFF Rio Triathlon circuit, in Recreio dos Bandeirantes, Rio de Janeiro City, on 08/27/2017. Blood markers of creatine kinase (CK), lactate dehydrogenase (LDH), lactate, oxidative stress (Lipid peroxidation (LP), carbonylated proteins (CP),  $\alpha$ -diphenyl- $\beta$ -picrylhydrazyl (DPPH), total thiols (TT)), and dehydration level were collected in two moments: baseline and Post-Race. Blood samples were collected using mineral-free needles (25 X 0,7 mm), the blood samples (14 ml) collected by the cubital vein, with the individuals remaining in a seated position in a tent pre- and post-race. Descriptive statistics were applied to and the Shapiro-Wilk (SW) test was used to verify normality of data. Paired Student's t-test was used to analyze the intragroup comparisons. Significance level was  $p < 0.05$ .

#### RESULTS:

The variables of injury and muscle fatigue CK, LDH and lactate presented a significant increase ( $p < 0.05$ ) comparing the baseline and post-race data. It was observed a significant increase in CP and a significant decrease in DPPH ( $p < 0.05$ ) in post-race. No significant changes in LP and TT oxidative stress markers variables was verified.

#### CONCLUSION:

Usually, the antioxidant system is not enough to eliminate oxidative damage during and after exercise, although the body's complex antioxidant defense system. Oxidative damage in exercise depends on its type and intensity. However, studies have shown that endurance training improves antioxidant defense as well as oxidative capacity in skeletal muscle. Seems to exist a dose-response relationship between adaptations of antioxidant enzymes and responses to ultra-endurance exercise, related to volumes and intensities of activity associated with ultra-endurance training confer protection against increases in free radical damage, resulting in improved oxidative balance. Even with the significant increase in fatigue, with the significant increase in the injury markers, the markers of oxidative stress suggested a good antioxidant defense.

### IRON METABOLISM REGULATION IN ENDURANCE-TRAINED FEMALES USING ORAL CONTRACEPTIVES

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#### INTRODUCTION:

Oral contraceptives (OC) are being highly widespread worldwide during the last decades due to their popular use in premenopausal women. In addition, sportswomen are frequent users of OC, which have been related with iron status. Inflammation and increases in IL-6 are produced by intense endurance exercise, up-regulating hepcidin levels. Moreover, sex hormones may also play a role, since estrogen has been suggested to downregulate hepcidin in vitro and in animals, while progesterone has been proposed to exhibit opposite effects1. However, there are some studies showing controversial results regarding sex hormones and hepcidin. Therefore, the purpose of this study was to compare the influence of sex hormones on iron, hepcidin and IL-6 regulation in physically active females using OC.

#### METHODS:

Sixteen endurance-trained females and monophasic OC users (25.3 $\pm$ 4.7 yrs; 56.1 $\pm$ 5.4 kg; 162.4 $\pm$ 5.7 cm; 47.4 $\pm$ 5.5 ml/kg/min) performed an intervallic running protocol in the two OC hormonal status (withdrawal and active pill phases). This protocol consisted of 8 x 3-minutes intervals at 85% of the maximal aerobic velocity (VO<sub>2</sub>max speed) with 90-seconds recoveries at 30% VO<sub>2</sub>max speed between them. Blood samples were taken pre-exercise, 0h, 3h and 24h post-exercise. Non-parametric statistical tests were applied to compare hepcidin, iron and IL-6 response between hormonal status (Wilcoxon test) and among times (Friedman ANOVA).

#### RESULTS:

Hepcidin showed a trend to significance ( $p = 0.059$ ) between withdrawal (1.76 $\pm$ 2.56 nM/ml) and active pill phase (1.39 $\pm$ 2.01 nM/ml). Iron concentrations were higher ( $p < 0.001$ ) in the active pill phase (131.54 $\pm$ 47.17  $\mu$ g/dl) compared to withdrawal phase (105.67 $\pm$ 50.83  $\mu$ g/dl). In contrast, there were no differences between phases for IL-6 (withdrawal phase: 2.13 $\pm$ 1.21 pg/ml; active pill phase: 2.09 $\pm$ 1.18 pg/ml;  $p = 0.581$ ). Furthermore, hepcidin was higher 3h post-exercise (3.08 $\pm$ 3.70 nM/ml) compared to pre-exercise (0.83 $\pm$ 0.70 nM/ml;  $p < 0.001$ ), 0h (1.13 $\pm$ 1.34 nM/ml;  $p = 0.003$ ) and 24h post-exercise (1.25 $\pm$ 1.58 nM/ml;  $p = 0.054$ ). Additionally, IL-6 levels peaked at 0h post-exercise (3.49 $\pm$ 1.58 pg/ml;  $p < 0.001$ ) being higher than pre-exercise (1.67 $\pm$ 0.55 pg/ml;  $p < 0.001$ ), 3h (1.73 $\pm$ 0.57 pg/ml;  $p < 0.001$ ) and 24h post-exercise (1.56 $\pm$ 0.28 pg/ml;  $p < 0.001$ ).

#### CONCLUSION:

Hepcidin levels showed by OC users seem to be lower during the active pill phase where endogenous hormones are suppressed and exogenous hormones remain stable. This finding does not agree with the only study analysing hepcidin between OC phases, which showed no differences2. Curiously, IL-6 did not change between OC phases suggesting that differences found in hepcidin are likely due to sex hormones influence. These discrepancies found between our study and the literature may be explained by the hormonal doses contained in monophasic OC. Funding: Contract DEP2016-75387-P.

### THE EFFECT OF NORMOBARIC HYPOXIA ON STRENGTH ADAPTATIONS TO RESISTANCE TRAINING IN OLDER ADULTS

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#### INTRODUCTION:

The use of systemic hypoxia (low O<sub>2</sub>) during resistance training is gaining popularity in young athletic populations. This training strategy is based on the mounting evidence that hypoxia elicits superior muscle hypertrophy and strength gains in young men, compared to training in normal conditions (normoxia). Hypoxic training could also benefit older adults, who typically experience progressive declines in muscle mass and strength, increasing their risk of falls and frailty. Although resistance training is somewhat effective for maintaining skeletal muscle in older adults, low muscle mass and strength continue to cause injury, disability and low quality of life. This study therefore aimed to determine the responses of older adults to hypoxic resistance training, to determine its safety and effectiveness as a training method for older adults.

**METHODS:**

Males and females aged 60-80 were recruited into an 8-week single-blinded randomised trial, performing resistance training in either normobaric hypoxia (14.4% O<sub>2</sub>) or normobaric normoxia (20.93% O<sub>2</sub>). Participants performed resistance exercises at 70% of their pre-determined one repetition maximum (1RM), using four upper and lower body exercises twice weekly. Aerobic fitness (VO<sub>2</sub>max), muscular endurance (isokinetic dynamometry), 1RM and body composition (DXA) were assessed pre- and post-training. Venous blood samples were collected throughout the first and last training session of the 8-week program to analyse haematological parameters, lactate, glucose and growth hormone. Data were analysed using repeated measures ANOVA (n=10 normoxia, 10 hypoxia), with Šidák post hoc testing.

**RESULTS:**

Participants in both groups made significant improvements in 1RM for leg extension, pectoral fly, row and squat, however hypoxia did not augment this response. Training in hypoxia did not augment VO<sub>2</sub>max or muscular endurance responses after the 8-week intervention, with no improvements seen in either group. Fat mass and lean mass remained unchanged in both groups. Hypoxia did not augment the acute blood lactate, glucose or haematological responses in the initial training session, nor after the 8-week intervention. Initially, there were no effects of hypoxia on the acute growth hormone response to resistance exercise. However, after the 8-week training intervention, the acute GH response was blunted in hypoxia in the 60-mins post exercise, compared to normoxia.

**CONCLUSION:**

We have established that older adults do not experience additional benefits from performing resistance training in hypoxia when compared to performing resistance training at sea level. From a safety perspective, the added cardiorespiratory stress of environmental hypoxia appears unjustified in the older adult population for this type of training.

### **EFFECT OF DIFFERENT LEVELS OF ACUTE HYPOXIA ON ORAL GLUCOSE TOLERANCE, INFLAMMATION, OXIDATIVE STRESS AND APPETITE IN OVERWEIGHT AND OBESE MEN.**

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**INTRODUCTION:**

Obesity is associated with increased inflammatory cytokines and insulin resistance. Hypoxia increases skeletal muscle glucose transport and disposal (Mackenzie & Watt, 2016), reduces appetite and increases metabolic rate (Palmer & Clegg, 2014). However, lower fractions of inspired oxygen (O<sub>2</sub>) have been shown to increase inflammation and oxidative stress compared to moderate hypoxia (Siervo et al., 2014). The aim of this study was to examine the effect of different levels of hypoxia on glucose tolerance, inflammation, oxidative stress and appetite in overweight and obese men.

**METHODS:**

In a single blind, randomised, balanced, crossover design, 6 overweight/obese men (BMI; 27.8 ± 1.2 kg/m<sup>2</sup>) completed the study (a priori power calculation = 12). Participants attended 3 separate visits, during which they inspired different fractions of O<sub>2</sub> (20.9%; [normoxia] 15.5%; 12.0%) for 1 h prior to a 3 h oral glucose tolerance test (OGTT; 75g). Plasma [glucose], [insulin], [ghrelin], [4-hydroxynonenal], [interleukin-6], systolic blood pressure (SBP), diastolic BP (DBP) and hunger were measured at baseline, after the intervention and at 30 min intervals during the OGTT. Arterial O<sub>2</sub> saturation (SPO<sub>2</sub>) and expired gas analysis were averaged over each hour. Repeated measured ANOVAs (oxygen fraction x time) and post-hoc tests were performed.

**RESULTS:**

SpO<sub>2</sub> decreased as the degree of hypoxia increased (p<0.0001). Area under the curve (AUC) [glucose] (20.9%: 34.2 ± 6.5; 15.5%: 37.3 ± 6.6; 12.0%: 38.5 ± 7.5 mmol.L<sup>-1</sup>, p=0.30) and peak [glucose] (20.9%: 6.9 ± 1.6; 15.5%: 7.0 ± 1.3; 12.0%: 7.5 ± 1.3 mmol.L<sup>-1</sup>, p=0.28) were not different between conditions. Total energy expenditure was not different between conditions (p=0.08). There was a significant reduction in carbohydrate (CHO) oxidation at the highest level of hypoxia (20.9%: 345 ± 55; 15.5%: 283 ± 93; 12.0%: 263 ± 14 kcal.4h<sup>-1</sup>, p=0.02) but no change in fat oxidation (p=0.12) between conditions. There was no effect of hypoxia on hunger (p=0.14), SBP (p=0.32) or DBP (p=0.40).

**CONCLUSION:**

Interim analysis suggests that high levels of hypoxia (12.0%) may reduce CHO oxidation in overweight/obese men, whereas peak plasma [glucose] and AUC do not change during an OGTT. Together this suggests that glucose storage may be increased with acute hypoxia.

Supported by Sporting Edge.

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## **OP-PN04 Nutrition**

### **DO ACTIVE ADOLESCENTS EAT BETTER?**

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**INTRODUCTION**

Health habits such as diet and physical activity have a major impact on adolescents' health status. Moreover, habits acquired during adolescence tend to be repeated in adult life. Previous research has shown that healthy habits are related to each other; however, objective



measures have not always been used to establish this relationship. The aim of this study was to analyze if adolescents with higher levels of physical activity have a better nutritional profile.

#### METHODS

A cross-sectional study was conducted in 236 students ( $13.28 \pm .55$  years), age range 13-15 years (127 boys, 109 girls), from a northern Spain city. A convenient and volunteer sampling was used.

Participants worn ActiGraph GT3x accelerometers on the waist for 7 days during waking hours, except for water activities. Results were analysed using Actilife v.6. Evenson's cut points for physical activity and Choi's algorithm to exclude non-wear time were used. Subjects were selected as active or inactive taking into account the minimum MVPA recommendations per day (WHO, 2010). Regarding nutritional profile, a food frequency questionnaire was used (Trinidad et al., 2008) to know weekly usual food habits. Foods were grouped using the categories of the Spanish Community Nutrition Society (SENC, 2018).

Descriptive statistic was carried out. Subsequently, Levene's test and independent t-test were performed. An alpha level of 0.05 was employed.

#### RESULTS

The most consumed foods were cereals ( $18.24 \pm 10.73$ ), dairy ( $16.73 \pm 8.36$ ) and pastries and sweets ( $15.65 \pm 10.75$ ). Fruits had an average consumption ( $12.04 \pm 8.7$ ). There was a low consumption of vegetables and greens ( $7.03 \pm 6.73$ ) and white meat ( $2.83 \pm 1.95$ ).

Active subjects consumed significantly more eggs than the inactive ones ( $3.40 \pm 2.47$  vs  $2.81 \pm 1.66$  respectively,  $p < 0.05$ ). Active adolescents had higher consumption of vegetables and greens, fruits, nuts, fish, and less consumption of pastries and sweets, although no significant differences were observed.

Regarding gender, women consumed significantly more fruits than men ( $13.26 \pm 10.21$  vs  $11.05 \pm 6.84$  respectively,  $p < 0.05$ ). This situation happened at the entire sample level and separating them in active and inactive.

#### CONCLUSIONS

Adolescents' food habits could improve for example reducing the pastries and sweets consumption and increasing the amount of vegetables and greens. According to previous literature, the relationship between health habits is confirmed again, this time between physical activity levels and diet quality.

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### **EFFECTS OF TWO MONTHS OF VERY LOW CARBOHYDRATE KETOGENIC DIET ON BODY COMPOSITION, MUSCLE STRENGTH, MUSCLE AREA AND BLOOD PARAMETERS IN COMPETITIVE NATURAL BODY BUILDERS**

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#### INTRODUCTION:

Ketogenic diet (KD) is a nutritional approach that restricts daily carbohydrates, replacing the majority of reduced energy with fat, while maintaining an adequate quantity of protein. Despite the increasing use of KD on weight control and other health outcomes, there are still many concerns about the use of KD on sport performance and its effects on muscle mass. The theoretical bases underlying the relationship between KD and muscle mass regulation system suggest a possible negative effect (1). Thus, the present study sought to investigate the influence of a KD on body composition, muscle area, muscle strength and blood parameters in competitive natural body builders

#### METHODS:

Eighteen natural competitive body builders aged ( $28.5 \pm 3.2$ ) were randomly assigned to ketogenic diet (KD  $n=16$ ) or to a western diet (WD  $n=16$ ). Diets had the same amount of protein ( $2.5 \text{ g/Kg/body weight/day}$ ). Carbohydrates were less than  $50 \text{g/day}$  ( $<5\%$  of daily energy intake - DEI) in the VLCKD whilst carbohydrates provided about  $55\%$ , of DEI in the WD. Fat mass, muscle mass and visceral adipose tissue VAT were measured by DXA. Cross sectional area CSA of quadriceps and arm flexors was measured by ultrasound and muscle strength was assessed by 1 RM arm curl and squat test. Resting energy expenditure (REE), respiratory exchange ratio (RER) were measured by indirect calorimetry. Standard blood biochemistry, testosterone, T3, IGF-1, BDNF and inflammatory cytokines (IL6, IL1B, TNFA) were measured. Energy requirement was calculated as  $45 \text{ Kcal per Kg of body weight/day}$ . A 2 Way ANOVA was used to investigate between and within group differences and a 2 (groups)  $\times$  3 (time points) mixed-model RM ANOVAs were utilized to determine differences in post-exercise BDNF at baseline and post-intervention.

#### RESULTS:

Body fat ( $p=0.037$ ) and VAT ( $p=0.002$ ) decreased significantly in KD compared to WD group. Maximal strength increased in both groups with no differences between groups. Total lean mass, quadriceps and arm flexors muscle CSA increased significantly (respectively:  $p=0.023$ ,  $p=0.031$ ,  $p=0.041$ ) more in WD compared to KD. KD showed a significant decrease of blood triglycerides ( $p=0.0023$ ), glucose ( $p=0.039$ ), insulin ( $p=0.0082$ ) and inflammatory cytokines compared to WD whilst post-exercise BDNF increased in both groups with significant greater changes in KD ( $p=0.021$ ). Other hormones and blood chemistry values showed no significant changes. There were no changes for absolute and relative REE in both groups whilst RER decreased significantly in KD ( $p=0.0008$ ).

#### CONCLUSION:

Our data confirm that KD reduces fat mass, has a blunting effect on muscle growth but, surprisingly, does not affect maximal strength. A KD seems to improve some health markers and increase BDNF acute response to exercise. In conclusion, KD may be used during body building preparation for health and leaning purposes but with the caution that hypertrophic muscle response could be blunted.

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### **EFFECTS OF DEHYDRATION ON A JUDO-SPECIFIC PERFORMANCE TEST**

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#### INTRODUCTION:

During the last days before competition, dehydration strategies are common practice in judo in order to reach the desired competition body weight. However little is known about the effects of dehydration on sport-specific performance in elite judokas. The judo-specific

Sterkowicz test (Franchini et al., 2009) mimics intensity and movements that are typical during judo combat. We aimed to study the effect of dehydration on performance and effort during 5 repeated Sterkowicz tests to imitate a one-day judo tournament.

**METHODS:**

Seventeen (11 male, 6 female,  $22.2 \pm 4.5$  years) elite judokas were tested twice interspersed with at least one week. On each test day they had to complete 5 Sterkowicz tests with 4 minutes rest in between during which they were not allowed to eat or drink. Before the second test day the judokas were instructed to lose at least 3% of their baseline body weight by dehydrating, following a self-chosen protocol. Before each test, body weight (Allscales, 2g accuracy), body composition (InBody S10 Bio Impedance Analysis) and urine specific gravity (USG) (Atago Refractometer) were measured. Heart rate (HR) was monitored continuously, and during each of the 5 test bouts the number of throws were counted allowing the calculation of the Sterkowicz index for each test bout as follows: (HR at end – HR at 1 min post)/number of throws. After each of 5 test bouts perceived exertion was rated (RPE) on a 10-points Borg scale. Body weight, body composition parameters and USG were compared between conditions using paired samples t-tests. The number of throws and Sterkowicz indices were analysed by conducting a repeated measures ANOVA with condition as the between-subjects factor (2 levels: baseline and dehydrated) and time as the within-subjects factor (5 levels for each Sterkowicz test bout).

**RESULTS:**

At the second test day, athletes lost  $3.7 \pm 1.6\%$  of their body weight and lower values for intracellular water ( $28,5 \pm 5,3$  vs.  $27,7 \pm 4,9$  litre;  $p=0.001$ ), extracellular water ( $16,8 \pm 3,1$  vs.  $16,2 \pm 2,9$  litre;  $p<0.001$ ) and USG ( $1,012 \pm 0,007$  vs.  $1,023 \pm 0,004$  g/cm<sup>3</sup>;  $p<0.001$ ) were measured. In each condition, RPE increased similarly from the first to the fifth test bout (within effect), but no between conditions effect was detected. In each condition the number of throws remained stable, however a significant between effect ( $p = 0.025$ ) for the number of throws and the Sterkowicz index ( $p=0.015$ ) were registered.

**CONCLUSION:**

Mild dehydration negatively effects intermittent judo performance. For the same perceived effort and physiological stress, fewer throws were performed. These results raise the concern that judokas might not experience the detrimental effects of dehydration because they perform with maximal effort regardless of their hydration status.

Key words: dehydration, judo, Sterkowicz test

**Reference**

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**NUTRITIONAL PERIODIZATION: ASSESSMENT OF ENERGY EFFICIENCY OF WELL-TRAINED CYCLISTS, MEDIATED BY THE GLYCOGEN THRESHOLD HYPOTHESIS**

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**INTRODUCTION:**

The manipulation of endogenous and exogenous glycogen availability has been suggested to influence body composition and endurance performance [1]. The aim of this study was to investigate whether the application of a proposed periodized glycogen availability strategy [2] improves cycling efficiency at the maximal lactate steady state (MLSS) in well-trained cyclists.

**METHODS:**

Eight well-trained cyclists (age:  $22.5 \pm 2.7$  years,  $VO_{2max}$ :  $73.0 \pm 6.5$  mL/kg/min) completed five weeks of controlled training while following a periodized feeding plan based on body weight and training workload. All participants initiated between two and three training sessions per week with low muscle glycogen availability. Accumulated time at MLSS (15 min blocks at MLSS interspersed with 2 min of active rest at 70% of the MLSS, continued until exhaustion), energy substrate utilization (measured through the respiratory exchange ratio), mean heart rate and pedaling cadence during exercise at MLSS, the final lactate concentration, and anthropometric parameters were measured before and after the 5-week intervention.

**RESULTS:**

After 5 weeks of nutritional periodization and controlled training, there was a significant increase in the individual MLSS ( $238.4 \pm 18.8$  watts to  $252.7 \pm 21.6$  watts;  $p=0.012$ ). However, accumulated time at MLSS worsened after the intervention ( $84.2 \pm 31.4$  min to  $79.4 \pm 29.9$  min;  $p=0.017$ ). The use of different energy substrates at MLSS did not change after the intervention (N.S). Similarly, there were no differences between the final lactate, pedaling cadence or mean heart rate at MLSS pre- and post-intervention (N.S). There was an improvement in the body composition of the participants, including a lower percentage of body fat and a higher percentage of muscle mass ( $p=0.012$  and  $p=0.025$ , respectively).

**CONCLUSION:**

The results of this study suggest that five weeks of controlled training and periodized nutrition (manipulating glycogen availability pre-exercise) may be a good strategy to improve the body composition and endurance performance of well-trained cyclists. However, it may not be a not a good strategy to modify substrate utilization or to increase the accumulated time at MLSS. The worse accumulated time at MLSS observed after the intervention may be due to a faster depletion of the glycogen stores as a consequence of the higher MLSS absolute intensity.

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**ACCURATE ESTIMATION OF EXOGENOUS CARBOHYDRATE OXIDATION DURING EXERCISE REQUIRES A LOW NATURAL ABUNDANCE 13C-CARBOHYDRATE "BACKGROUND" TRIAL.**

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Funding: Biotechnology and Biological Sciences Research Council and Volac International

**Introduction:**

The efficacy of ingested carbohydrate (CHO) sources as fuels for improving endurance exercise performance is often inferred from exogenous CHO oxidation rates, with quickly oxidized CHOs reliably improving exercise performance. Exogenous CHO oxidation can be estimated

by measuring breath  $^{13}\text{CO}_2$  production after ingesting high natural abundance  $^{13}\text{C}$  CHOs during exercise. However, expired  $^{13}\text{CO}_2$  can also arise from oxidation of stored CHO (glycogen), which would lead to overestimation of exogenous CHO oxidation. This background shift is often corrected for by measuring breath  $^{13}\text{CO}_2$  production during a “water” trial, but this fails to account for the known effects of CHO feeding on substrate utilization. The aim of this study was to compare exogenous CHO oxidation rates of sucrose or lactose during exercise, estimated after background correction using water or sugar-specific low natural abundance  $^{13}\text{C}$  CHOs.

Methods:

11 participants ( $22 \pm 4$  years,  $50.9 \pm 4.7$  ml.min<sup>-1</sup>.kg<sup>-1</sup>; 8 males, 3 females) cycled at 50%W<sub>max</sub> for 150 min, 5 times, while ingesting water, lactose with low ( $-27.73$  delta ‰ versus Pee Dee Bellemnitella) and high ( $-16.29$  delta ‰) natural abundance  $^{13}\text{C}$ , and sucrose with low ( $-26.13$  delta ‰) and high ( $-11.87$  delta ‰) natural abundance  $^{13}\text{C}$ , at a rate of 0.8 g.min<sup>-1</sup> (48 g.h<sup>-1</sup>). Exogenous CHO oxidation after high natural abundance  $^{13}\text{C}$  CHOs was estimated from  $^{13}\text{CO}_2$  production during exercise by combined measurement of expired breath  $^{13}\text{C}:^{12}\text{C}$  ratio (isotope-ratio mass spectrometry) with  $\text{CO}_2$  production (indirect calorimetry). Exogenous CHO oxidation was calculated after correction for background shifts in  $^{13}\text{CO}_2$  production determined in the water or corresponding sugar-specific low natural  $^{13}\text{C}$  CHO trials. Paired t-tests were used to compare exogenous CHO oxidation rates of lactose or sucrose using the two correction methods.

Results:

Exogenous CHO oxidation rates (Mean  $\pm$  SD, 60 – 150 min exercise period) of sucrose were  $0.61 \pm 0.10$  g.min<sup>-1</sup> and  $0.69 \pm 0.15$  g.min<sup>-1</sup> using a low  $^{13}\text{C}$  CHO-correction and water-correction, respectively ( $P < 0.01$ ). For lactose, exogenous CHO oxidation rates using the two methods were  $0.56 \pm 0.19$  g.min<sup>-1</sup> and  $0.51 \pm 0.16$  g.min<sup>-1</sup>, respectively ( $P = 0.22$ ). Water-correction significantly overestimated sucrose oxidation rates by 14%, and underestimated lactose oxidation rates by 10%, though non-significantly.

Conclusions:

Using a water-correction significantly overestimated sucrose oxidation, and non-significantly under-estimated lactose oxidation. Past studies using a water background trial may have inaccurately estimated exogenous CHO oxidation. Future studies using naturally high abundance  $^{13}\text{C}$  CHOs to calculate exogenous CHO oxidation should use a CHO specific low  $^{13}\text{C}$  background trial.

## **DRINKING TO THIRST IS NOT ADEQUATE TO OPTIMIZE PROLONGED CYCLING PERFORMANCE IN A WARM ENVIRONMENT**

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INTRODUCTION:

Proper hydration is important to maintain cardiovascular and thermoregulatory functions and optimize performance during prolonged endurance exercise. For exercise lasting 1 to 2 hours, programmed fluid intake (PFI) and ad libitum drinking have similar effects on cycling and running endurance performance (1). To our knowledge, the impact of the fluid intake strategy on endurance performance during exercise lasting more than 3 hours has yet to be studied in a controlled environment. Therefore, the aim of this study was to compare the effect of PFI and thirst driven fluid intake (TDFI) on prolonged cycling performance.

METHODS:

Eight male endurance athletes ( $26 \pm 6$  yrs;  $\text{VO}_2\text{peak}$  :  $67 \pm 4$  mL/kg/min) were recruited to complete two experimental trials consisting of 5 hours of cycling on a Computrainer<sup>TM</sup> at 60%  $\text{VO}_2\text{peak}$  followed by a 20 km time-trial (TT) in a randomized, crossover and counterbalanced sequence. The experiments were conducted under a warm ambient temperature (30°C, 35% relative humidity). A familiarization trial consisting of 2 hours at 60%  $\text{VO}_2\text{peak}$  followed by a 20 km TT was used to estimate the fluid intake needed to limit the body mass loss to 1% for the PFI condition. During the TDFI trial, participants were requested to drink based on their perceived thirst.

RESULTS:

This is an ongoing study; hence findings are reported for  $n=6$ . Fluid consumption was greater for PFI with 7082 mL, compared to 5246 mL for TDFI. Body mass loss reached 1.3% for PFI, compared with 2.7% for TDFI. Average power output for the 20 km TT was higher ( $p < 0.05$ ) for PFI ( $279 \pm 44$  W) than TDFI ( $264 \pm 46$  W). A time ( $p < 0.01$ ), but not condition or interaction effect was observed for heart rate and rectal temperature. At the end of the 5 hours at a fixed workload, blood sodium was higher ( $p < 0.05$ ) for TDFI ( $144 \pm 2$  mmol/L) than PFI ( $140 \pm 3$  mmol/L). There were no differences between conditions for perceived thirst, abdominal discomfort and perceived heat stress, but a higher perceived exertion was observed during TDFI ( $p = 0.05$ ).

CONCLUSION:

These preliminary results suggest that TDFI may not optimize performance during a prolonged cycling exercise in a warm environment, so endurance athletes competing in the heat for 5 hours may benefit from planned fluid intake that aims to limit their body mass loss to ~1%.

## **IMPACT OF CARBOHYDRATE INTAKE AFTER ENDURANCE EXERCISE ON BREATH ACETONE LEVELS AND PERFORMANCE RECOVERY**

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INTRODUCTION:

Insufficient carbohydrate (CHO) intake after endurance exercise augmented fat metabolism with delayed recovery of endurance exercise performance during post-exercise (Alghannam et al., 2015). We hypothesized that enhanced post-exercise fat metabolism by insufficient CHO intake would reflect delayed recovery of endurance performance. Therefore, the purpose of the present study was to determine the impact of CHO intake following endurance exercise on breath acetone levels and recovery of endurance performance during post-exercise period.

METHODS:

Eight males (age:  $22 \pm 0.54$  yrs, weight:  $63.15 \pm 1.28$  kg,  $\text{VO}_2\text{max}$ :  $46 \pm 1.8$  mL/min/kg) conducted two trials, consisting of either low CHO trial (LCHO trial) or high CHO trial (HCHO trial). In each trial, subjects came to the laboratory at 8:00 following an overnight fast. They commenced glycogen depleting exercise (EX1, 2 min exercise at 90~70% of  $\text{VO}_2\text{max}$  followed by 2 min exercise at 50% of  $\text{VO}_2\text{max}$  until exhaustion, van Loon et al., 2000). Immediately after and 30 min after EX1, subjects consumed either high CHO meal (2.4g per body weight) in HCHO trial or low CHO meal (0.6g per body weight) in LCHO trial. A two hour of recovery period was set after EX1 to evaluate time course changes in breath acetone levels and serum total ketone body concentrations. At 2 h after completing glycogen depleting exercise, subjects started cycling exercise at 65% of  $\text{VO}_2\text{max}$  (EX2). Time to exhaustion during EX2 was determined to evaluate endurance performance.

RESULTS:

Time to exhaustion during EX2 was significantly longer in HCHO trial ( $50 \pm 3$  min) than in LCHO trial ( $40 \pm 3$  min,  $p = 0.02$ ). In the LCHO trial, breath acetone levels markedly increased 105 min after EX1. Immediately after EX2, LCHO trial presented significantly higher breath acetone levels compared with HCHO trial (HCHO:  $0.35 \pm 0.05$  ppm, LCHO trial:  $0.64 \pm 0.06$  ppm,  $p < 0.001$ ). Furthermore, a significant inverse correlation was observed between breath acetone levels at 105 min after EX1 and time to exhaustion during EX2 ( $r = -0.711$ ,  $p = 0.047$ ). Serum total ketone body concentrations were significantly higher in LCHO trial ( $190 \pm 47$   $\mu\text{mol/L}$ ) than in HCHO trial ( $21.5 \pm 2$   $\mu\text{mol/L}$ ) at 120 min after EX1 ( $p = 0.01$ ).

#### CONCLUSION:

Insufficient CHO intake after endurance exercise increased breath acetone levels during post-exercise, with delayed recovery of endurance performance. These results suggest that breath acetone levels during post-exercise may reflect delayed recovery of endurance performance by lowered CHO availability.

## OP-PN05 Supplements and ergogenic aids

### POST-EXERCISE CARBOHYDRATE FEEDING DOES NOT ACCELERATE FORCE RECOVERY AFTER GLYCOGEN-DEPLETING FOLLOWED BY HIGH-INTENSITY EXERCISE IN HUMANS

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#### INTRODUCTION:

Prolonged low-frequency force depression (PLFFD) induced by fatiguing exercise is characterized by a persistent depression in submaximal contractile force during the recovery period. Muscle glycogen depletion is known to induce fatigue during prolonged exercise, and by accelerating glycogen re-synthesis, post-exercise carbohydrate intake can facilitate recovery and improve the capacity for repeated bout of endurance exercise. Short-term, high-intensity exercise can cause PLFFD without a substantial decrease in glycogen and hence via other mechanisms that, for instance, might involve increases in reactive oxygen/nitrogen species (RONS). The aim of the current study was to determine whether the recovery of PLFFD induced by glycogen-depleting followed by high-intensity sprint cycling exercise is accelerated by carbohydrate supplementation, and consequently glycogen re-synthesis.

#### METHODS:

We used a randomized cross-over study design where recreationally active males ( $n=9$ ) consumed either a 10 % carbohydrate (1.5 g/kg/h, glucose and fructose ratio 2:1) or placebo (PLA) beverage for 3 h after 60 min of glycogen-depleting cycling exercise followed by six 30 s all-out sprints (Wingates tests) interspaced with 4 min of recovery. The sessions were separated by four weeks. Neuromuscular testing with transcutaneous electrical stimulation of the quadriceps muscle was performed to determine the extent of PLFFD by eliciting low-frequency (20 Hz) and high-frequency (100 Hz) stimulation torques. Muscle glycogen concentration was determined from the needle biopsy samples of m. vastus lateralis at baseline, immediately post-exercise, and after 3 h of recovery period. Paired t-tests were used to compare the rate of muscle glycogen re-synthesis between the two experimental trials. For the analysis of the torques, two-way repeated measures analysis of variance was used to assess the effect of time and supplementation (CARB vs. PLA). The  $\alpha$ -level of significance was set at  $P < 0.05$ .

#### RESULTS:

Muscle glycogen was severely depleted after exercise, reaching  $\sim 2-4$  % of the fasted state baseline value, and re-synthesis rate during the 3 h recovery period was 2.5-fold faster in the CARB vs. PLA condition (13.7 vs. 5.4 mmol glucosyl units/kg wet weight/h, respectively). Torque at 20 Hz was significantly more depressed than 100 Hz torque during the recovery period in both conditions, and the rate of the recovery of PLFFD (20/100 Hz ratio) did not differ between the two trials.

#### CONCLUSION:

The current study demonstrated that post-exercise carbohydrate feeding enhances glycogen re-synthesis but does not affect the acute recovery of PLFFD induced by a combination of glycogen-depleting and all-out sprint cycling exercise. Thus, with this type of exercise, we believe that PLFFD is mainly caused by RONS-dependent mechanisms that are not mitigated by enhanced restitution of muscle glycogen stores, at least during the early phase of recovery.

### GLUCOSAMINE AS A PERFORMANCE ENHANCING SUBSTANCE IN EXERCISE

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#### INTRODUCTION:

Glucosamine (Glc) is a commonly used dietary supplement to promote cartilage health in humans, which also acts as an inhibitor of glycolysis by inhibiting both glucokinase and hexokinase. It has been previously shown that Glc, through the generation of reactive oxygen species, activates AMP-activated protein kinase and increases mitochondrial biogenesis and life span in mice. Endurance exercise performance is dependent on skeletal muscle mitochondrial density. We hypothesized that supplementation with Glc could act as a performance enhancing substance in trained mice.

#### METHODS:

Forty-eight young male mice were divided into 6 experimental groups ( $n=7-8$ ): sedentary+maltodextrin (G1); sedentary+Glc (500 mg x kg<sup>-1</sup>) (G2); trained+maltodextrin (G3); trained+Glc (250 mg x kg<sup>-1</sup>) (G4); trained+Glc (500 mg x kg<sup>-1</sup>) (G5); and trained+Glc (1000 mg x kg<sup>-1</sup>) (G6). The animals trained 4 days a week for 6 weeks, following a 45-minute continuous aerobic exercise protocol. We measured metabolic, functional, and performance parameters before and after the training protocol. A multivariate generalized linear model was conducted considering the factors Glc supplementation and physical exercise. A statistical level of  $p < 0.05$  was accepted. All data are expressed as mean  $\pm$  standard error of mean.

#### RESULTS:

We found a significant training-induced improvement in motor coordination (28.3 %,  $p < 0.01$ ), determined through the rotarod test, in the group of animals treated with the lowest dose of glucosamine (G4). Regarding endurance, both the G3 and G4 groups, improved 41 % ( $p < 0.05$ ) and 71.1 % ( $p < 0.01$ ) respectively, after the training period. No changes in grip strength, fasting blood glucose, and on the glucose tolerance test were found between the different experimental groups, before and after the interventions.

#### CONCLUSION:

A low dose of Glc in mice, equivalent to a translational dose in humans of 1400 mg x day<sup>-1</sup>, acts as an enhancing performance substance in exercise. The beneficial effects of Glc are lost at higher doses of the amino sugar. The synergistic effect of Glc with exercise training on mitochondrial biogenesis and the increase in oxidative metabolism, through modifications in the redox balance, deserves further studies.

### **EFFECTS OF BEETROOT JUICE INTAKE ON PERFORMANCE, HORMONAL AND MECHANICAL RESPONSES IN WELL-TRAINED CROSSFIT PRACTITIONERS**

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#### **INTRODUCTION:**

Performance in CrossFit (CF) workouts are mainly linked to improvements in anaerobic power and aerobic capacity (1). Acute beetroot juice (BJ) intake has demonstrated to improve aerobic and anaerobic performance (2, 3). However, no studies have evaluated the effects of BJ intake on CF performance by linking hormonal and mechanical responses. This study aimed to determine the causal physiological association between CF workouts performance and hormonal and mechanical responses after acute BJ intake.

#### **METHODS:**

Nine well-trained male (mean  $\pm$  SD: age = 28.4  $\pm$  4.1 years, body mass = 80.9  $\pm$  4.9 kg, height = 175.8  $\pm$  6.9 cm) practitioners undertook a CF workout after drinking 140 mL of BJ (~ 12.8 mmol NO<sub>3</sub><sup>-</sup>) or placebo. The two experimental conditions were administered using a randomized, double-blind, crossover design. The CF workout consisted of repeating the same exercise routine twice: Wall ball shots plus full back squat with 3-min rest (1st routine) or without rest (2nd routine) between the two exercises. A 3-min rest was established between the two exercise routines. Before and after the CF workout mechanical fatigue was assessed. Blood collection to determine nitrate-nitrite and hormone plasma concentrations (cortisol and testosterone) were performed under resting conditions (pretest) and after completing mechanical fatigue assessment (post-test). A two-way analysis of variance with repeated measures was applied to compare the effects of the two experimental conditions. A statistical level of  $p < 0.05$  was accepted. All data are expressed as mean  $\pm$  SD

#### **RESULTS:**

Nitrate-nitrite plasma concentrations were higher after BJ intake (377.7  $\pm$  84.4  $\mu$ M) than placebo conditions (25.9  $\pm$  6.0  $\mu$ M) ( $p < 0.001$ ). An interaction effect was observed in the number of repetitions performed ( $p = 0.01$ ). The Bonferroni test determined a higher number of repetitions after BJ (80.1  $\pm$  3.5) than placebo intake (76.9  $\pm$  4.7) when a 3-min rest between WB and FBS (1st routine) was established ( $p = 0.01$ ). An interaction effect was detected in cortisol response ( $p < 0.05$ ). Cortisol showed a higher increase after BJ compared to placebo intake (70% vs. 35%, respectively). No interaction effect was observed in the testosterone and testosterone/cortisol ratio ( $p > 0.05$ ). An interaction effect was verified in muscular fatigue ( $p < 0.05$ ) with a higher muscular fatigue being observed with BJ than placebo ( $p < 0.05$ ).

#### **CONCLUSION:**

BJ intake improved anaerobic performance only after the recovery time between exercises. This increase in performance in the first routine probably generated greater hypoxia in the muscle mass involved, possibly conditioning post-exercise performance. This was observed with a fall in muscle fatigue measured at the end of

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### **WHEY PROTEIN SUPPLEMENTATION DOES NOT ACCELERATE RECOVERY FOLLOWING A SINGLE BOUT OF ECCENTRIC EXERCISE**

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#### **INTRODUCTION:**

Eccentric exercise induces muscle damage, resulting in a transient decline in muscle function and performance. It is unclear whether protein supplementation can accelerate recovery following a bout of intense eccentric exercise. In the present study we investigated the impact of protein supplementation on recovery of muscle function and muscle soreness following unaccustomed eccentric exercise.

#### **METHODS:**

Forty recreationally active males (24 $\pm$ 4 y, BMI 23 $\pm$ 2 kg/m<sup>2</sup>) participated in a double blind, randomized, parallel placebo-controlled trial, comprising a 9-day supplementation period with twice daily supplementation of whey protein (PRO; 60 g/day) or an iso-energetic carbohydrate (CON). Measurements of muscle function, and soreness were conducted before, and 0, 3, 24, 48, and 72 h after performing 100 drop jumps on day 5 of the supplementation period. Muscle function was assessed by maximal voluntary isometric (60° knee angle) and isokinetic contractions (90 and 180°·s<sup>-1</sup> angular velocity) of the upper leg muscles and by countermovement jumps. Blood markers of muscle damage and inflammation included creatine kinase (CK) and C-reactive protein (CRP). Muscle soreness was assessed by Visual Analogue Scale (VAS). Mixed-model ANOVA was applied to assess whether recovery following eccentric exercise differed between groups. Data are presented as mean $\pm$ SD.

#### **RESULTS:**

No differences were observed between groups at baseline for any of the outcome variables. During the supplementation period, total protein intake increased from 1.1 $\pm$ 0.3 to 1.7 $\pm$ 0.2 g/kg/body mass in PRO and decreased from 1.2 $\pm$ 0 to 1.0 $\pm$ 0.2 g/kg/body mass in CON (time x treatment interaction,  $P < 0.0001$ ). After an initial decline in maximal voluntary isokinetic contraction at 180°·s<sup>-1</sup> from 129.1 $\pm$ 31.9 to 109.6 $\pm$ 30.6 (-14.9 $\pm$ 9.7%) and 134.3 $\pm$ 27.4 to 118.0 $\pm$ 28.2 N·m (-12.1 $\pm$ 11.6%) in PRO and CON, respectively, recovery of maximal voluntary isokinetic contraction at 180°·s<sup>-1</sup> was slower in PRO as opposed to CON (time x treatment interaction,  $P = 0.011$ ). In line, the recovery of maximal voluntary isokinetic contraction at 90°·s<sup>-1</sup> was also slower in PRO as opposed to CON (time x treatment interaction,  $P = 0.044$ ). In contrast, the recovery of maximal voluntary isometric contraction did not significantly differ between groups (time x treatment,  $P = 0.555$ ). Countermovement jump performance showed a transient decline following eccentric exercise, but changes did not differ between groups (time x treatment,  $P = 0.518$ ). CK and CRP showed a temporary increase (time effect,  $P < 0.0001$ ) over the 72h period, with no differences

between groups (time x treatment, both  $P > 0.570$ ). In line, muscle soreness as assessed by VAS displayed a transient increase over time ( $P < 0.0001$ ), with no differences between groups (time x treatment,  $P = 0.281$ ).

**CONCLUSION:**

Whey protein supplementation does not accelerate recovery of muscle function or attenuate muscle soreness during 3 days of recovery from a single bout of eccentric exercise.

**THE RECOVERY OF MARATHON-INDUCED METABOLIC ADAPTATIONS WITH AND WITHOUT BEETROOT JUICE INTERVENTION**

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**INTRODUCTION:**

Although endurance races (>5 km) are considered a popular global pastime, these events adversely affect athletes physiologically and immunologically, while inducing a variety of metabolomic adaptations. As such, numerous research approaches have been directed towards identifying cost-effective, readily available recovery agents such as functional foods (beetroot, cherry, pomegranate, bananas, etc.). These foods are rich in antioxidants and possess potent radical scavenging properties, which aid in the physiological and immunological recovery of athletes. To date, however, limited literature is available pertaining to the metabolic recovery of athletes after endurance races. As such, the current study aimed to elucidate the unaided recovery trend of athletes within 48h post-marathon, and to determine the effects beetroot ingestion on these recovery profiles.

**METHODS:**

In this double-blinded placebo-controlled study, serum samples of 31 marathon athletes, which were obtained 24h before, immediately after (d0), as well as 24h and 48h post-race, were analysed using an untargeted two-dimensional gas chromatography time-of-flight mass spectrometry approach. Supplementation intervention commenced after d0 sampling, subdividing athletes into beetroot (n=15) and placebo (n=16) ingesting cohorts. Multi-statistical approaches were employed to identify the metabolites significant pertaining to the stipulated aims.

**RESULTS:**

Unaided recovery of metabolites (n=61) were attained within 24 h post-marathon, with the exception of xylose, which recovered within 48 h post-race. Fluctuations in these metabolites indicated downregulation of fuel substrate catabolism pathways, the restoration of glycaemic flux, as well as possible activation of recovery mechanisms such as glycogenesis and uridine-dependent nucleotide synthesis. This trend was also seen in the beetroot-supplemented athletes, while traditional statistical inter-cohort comparisons of the recovery timepoints only indicated significantly higher concentrations of arabitol, nonadecanoic acid and xylose in the beetroot group. However, when employing a two-way mixed analysis of variance approach, significant correlations were denoted between various intermediates (carbohydrates, lipids and amino acids), with relation to supplement intervention (without time dependency) and factor interaction (supplement intervention and time).

**CONCLUSION:**

Metabolic recovery was attained within 48h post-marathon, regardless of the administered beetroot/placebo supplementation. As such, it appears that beetroot ingestion does not provide an added advantage in terms of metabolic recovery within 48h post-marathon when compared to unaided recovery. Nevertheless, a better understanding of the metabolic shifts that occur during recovery may provide insights to new, more efficient/targeted recovery approaches to improve athletic performance.

**EFFECTS OF DIFFERENT CARBOHYDRATE CONCENTRATIONS ON CYCLING EFFICIENCY DURING 2-H CYCLING**

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**INTRODUCTION:**

Gross efficiency (GE) is described as the ratio of mechanical work accomplished and metabolic energy expenditure and serves as a parameter of endurance performance. It was recently demonstrated that prolonged steady-state exercise reduces GE by elevating oxygen uptake and minute ventilation (VE) and that carbohydrate (CHO) ingestion has a small effect on the decline of GE [1,2]. CHO intake is suggested to increase performance during prolonged exercise and to alleviate the negative effects of depleted CHO stores [3]. Therefore, the aim of this study was to evaluate the effects of different concentrations of isomaltulose, a CHO with a low glycemic index, on GE during prolonged exercise.

**METHODS:**

Nine endurance-trained male triathletes (age:  $28.2 \pm 4.7$  yrs; stature:  $1.80 \pm 0.07$  m; body mass:  $75.6 \pm 8.0$  kg; maximal oxygen uptake:  $59.6 \pm 5.2$  mL/min/kg; maximal aerobic power [MAP]:  $373 \pm 41$  W) performed five cycling tests: A preliminary graded exercise test to determine first ventilatory threshold (VT) and MAP and four 2-h constant load exercises at  $\Delta 25\%$  intensity (25% of the difference between VT and MAP). During the trials, participants ingested 0.8 L/h lemon-flavoured drinks. The CHO-concentrations of the drinks were 0.0 %, 1.6%, 3.2%, and 4.8%, which equals 0 g/h, 20 g/h, 40 g/h, and 60 g/h and were administered in a randomised order. Heart rate (HR) was measured continuously and respiratory gases every 30 min to assess for GE, VE, oxygen uptake, and respiratory exchange ratio (RER). Rating of perceived exertion (RPE) and blood lactate concentration [La] were measured every 20 min. A two-way ANOVA was used to assess for multiple comparisons. Significance was accepted at  $p < 0.05$ .

**RESULTS:**

Significant main effects for concentrations were found for [La] ( $2.5 \pm 1.0$  mmol/L,  $2.1 \pm 0.6$  mmol/L,  $2.0 \pm 0.6$  mmol/L, and  $1.9 \pm 0.5$  mmol/L for placebo, 4.8%, 3.2%, and 1.6%, respectively;  $p = .046$ ), but not for GE ( $p = .932$ ), VE ( $p = .582$ ), oxygen uptake ( $p = .908$ ), RER ( $p = .952$ ), RPE ( $p = .244$ ), and HR ( $p = .494$ ). Significant main effects for time were found for GE, VE, oxygen uptake, RER, RPE, HR, and [La] (all at  $p < .001$ ). Non-significant interactions concentration\*time were found for GE ( $p = .820$ ), VE ( $p = .150$ ), oxygen uptake ( $p = .850$ ), RER ( $p = .820$ ), RPE ( $p = .074$ ), HR ( $p = .503$ ), and [La] ( $p = .200$ ).

**CONCLUSION:**

The findings of this study indicate that the ingestion of different concentrations of isomaltulose did not prevent a decrease in GE or RER. Moreover, the rise in oxygen uptake, VE, RPE scores, and HR was not significantly different between concentrations. Interestingly, [La] was

significantly higher in the placebo condition compared to CHO ingestion. It is suggested that CHO depletion has no influence on physiological measures during prolonged cycling exercise in the heavy intensity domain and furthermore, it seems that ingestion of isomaltulose is not related to the decline in GE.

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### INDUCED ALKALOSIS, GASTROINTESTINAL SYMPTOMS AND PALATABILITY OF SODIUM CITRATE INGESTION: THE IMPLICATIONS OF INGESTION DURATION

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#### INTRODUCTION:

Sodium citrate supplementation induces alkalosis (increased blood bicarbonate concentration ( $[HCO_3^-]$ )), but has been associated with mixed performance effects. Equivocal ergogenic effects may be due to sub-optimal supplementation protocols, with potential implications for induced alkalosis, gastrointestinal (GI) symptoms and the supplement's palatability. Specifically, the effect of ingestion duration on alkalosis, GI symptoms and palatability has yet to be established. The primary aim of this investigation was to compare alkalosis (peak concentration and time to peak concentration for  $[HCO_3^-]$ ), and subjective ratings of GI symptoms and palatability, after ingesting sodium citrate over different durations.

#### METHODS:

Using a repeated-measures, cross-over design, 16 healthy and active participants (1:1 female: male) ingested 500 mg.kg<sup>-1</sup> BM sodium citrate in capsules (1) over four different durations (15, 30, 45 and 60 min). Venous blood sampling was used to quantify  $[HCO_3^-]$  at baseline, and at 30 min intervals for 480 min post-ingestion; validated questionnaires quantified GI symptoms. Palatability was assessed immediately post-ingestion using a validated scale. Linear mixed models were fitted to compare ingestion durations.

#### RESULTS:

For each of the four ingestion protocols,  $[HCO_3^-]$  was significantly greater than baseline ( $p < 0.001$ ) at each post-ingestion time-point for 480 min. There were no significant differences between ingestion protocols for peak  $[HCO_3^-]$  ( $p = 0.501$ ); peak  $[HCO_3^-]$  ranged from 29.1 to 29.8 mmol.L<sup>-1</sup> (60 and 45 min ingestion duration, respectively). There were no significant differences between ingestion protocols for time to peak  $[HCO_3^-]$  ( $p = 0.077$ ), with a range of 223 to 290 min (45 and 60 min ingestion duration, respectively) after the onset of ingestion. GI symptoms were minimal for each ingestion duration (mean session ratings  $< 12$ , from a maximum of 720), and no differences were detected between ingestion durations for GI symptoms ( $p = 0.846$ ) or palatability ( $p = 0.190$ ).

#### CONCLUSION:

Results of this study indicated that 500 mg.kg<sup>-1</sup> BM sodium citrate ingestion in capsules, using different ingestion durations (15, 30, 45 and 60 min), induced similar levels of alkalosis. For all ingestion durations, alkalosis peaked approximately four hours post-ingestion, minimal GI symptoms occurred and no difference in palatability was observed. Elevated  $[HCO_3^-]$  for 480 min post-ingestion represents a longer persistence of induced alkalosis than that observed in prior research (1), so the pharmacokinetic profile of the supplement warrants further study. Based on the similarity of induced alkalosis, GI symptoms and palatability across sodium citrate ingestion durations, a 15 min ingestion duration may be preferable, as this imposes the lowest time-burden on athlete preparation.

1. Urwin CS, Snow RJ, Orellana L, Condo D, Wadley GD, and Carr AJ. Sodium citrate ingestion protocol impacts induced alkalosis, gastrointestinal symptoms, and palatability. *J Physiological reports* 7

### DIETARY NITRATE SUPPLEMENTATION COMBINED WITH EXERCISE IN HYPOXIA: EFFECTS ON PERFORMANCE

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#### INTRODUCTION:

Athletes are constantly seeking new procedures to enhance their performance. Altitude training, in any of its many forms, is one of the oldest performance optimizers (1). On the other hand, nutritional ergogenic aids have gained popularity, with dietary nitrate emerging as one of these in recent research (2). Given that exercise in hypoxia implies low oxygen availability, and therefore, could enhance the nitrate-nitrite-nitric oxide production pathway, the hypothesis that a combined long-term effect of both strategies is linked with a greater improvement in performance, is very appealing, yet, poorly understood.

#### METHODS:

Twelve trained male subjects (mean  $\pm$  SD; age: 37.3 $\pm$ 3.4 yr, height: 1.710.08 m and body mass: 69.5 $\pm$ 3.4 kg) performed high-intensity interval-training on a cycle ergometer (4 weeks, 3 sessions/week) in normobaric hypoxia (3000 m,  $\sim$ 14% FiO<sub>2</sub>) while ingesting, 3h before each session, either 150 ml of beetroot juice (Sabeet, Sabinsa Corporation): HNO, n = 6] or a control drink (HPL, n = 6). Before and after intervention, subjects performed 3 tests: (i) incremental until exhaustion for VO<sub>2</sub>max and corresponding power (pVO<sub>2</sub>max) assessment; (ii) 3-min all-out for critical power (CP) and curvature constant (W') assessment; (iii) severe intensity exercise (80%Δ) to exhaustion (Tlim). Cardiopulmonary parameters were assessed (10-s averaged) using a portable gas analyser (K5, Cosmed, Italy). Capillary blood samples were collected before and immediately after each test (Lactate Scout +, EKf, Germany: [La-]max). Comparisons between moments (Wilcoxon test) and groups (Mann-Whitney test) were done ( $p \leq 0.05$ ).

#### RESULTS:

Before intervention, there was no differences between groups in all parameters, excepted Tlim (HNO: 372 $\pm$ 63 vs. HPL: 541 $\pm$ 104 s,  $p < 0.05$ ). From week 1 to 4, W' decreased by 2% (11.8 $\pm$ 3.1 vs. 10.6 $\pm$ 3.3 kJ,  $p < 0.05$ ) in HNO group, and [La-]max increased by 14% after incremental test in HPL group (9.9 $\pm$ 1.7 vs. 11.2 $\pm$ 1.7 mmol.L<sup>-1</sup>,  $p < 0.05$ ). No differences were found for VO<sub>2</sub>max (HNO: 57.9 $\pm$ 6.3 vs. 56.9 $\pm$ 6.3 and HPL: 58.8 $\pm$ 7.6 vs. 61.1 $\pm$ 6.1 ml.kg<sup>-1</sup>.min<sup>-1</sup>), pVO<sub>2</sub>max (295 $\pm$ 14 vs. 301 $\pm$ 23 and HPL: 295 $\pm$ 31 vs. 306 $\pm$ 35 W) and CP (HNO: 258 $\pm$ 35 vs. 254 $\pm$ 36 and HPL: 275 $\pm$ 36 vs. 269 $\pm$ 27 W). After intervention, HNO evidenced lower [La-]max in the 3-min all-out test (HNO: 10.4 $\pm$ 1.3 vs. HPL: 12.6 $\pm$ 10.9 mmol.L<sup>-1</sup>,  $p < 0.05$ ). % change in Tlim was similar for both groups ( $\sim$ 5%).

#### CONCLUSION:

As previously reported (3, 4), we found similar training adaptations to hypoxic training, irrespective of whether the training was done alone or in conjunction with nitrate. However, possible performance benefits should be investigated with a higher number of subjects.

## Acknowledgments

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## THE EFFECT OF DIETARY NITRATE ON KNEE EXTENSOR PEAK ISOMETRIC FORCE AND RATE OF FORCE DEVELOPMENT IN HEALTH ADULTS

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## INTRODUCTION:

Dietary nitrate (NO<sub>3</sub><sup>-</sup>) has received considerable attention over the last decade with focus largely placed on the benefits for health and short-duration exercise performance (1). However, evidence suggests that NO<sub>3</sub><sup>-</sup> supplementation can sever to promote the contractile properties of skeletal muscle, particularly when considering rapid and forceful actions involving fast-twitch muscle fibres. Whilst studies have investigated the benefits of NO<sub>3</sub><sup>-</sup> for promoting muscle function, it remains that much of the focus has been placed on involuntary contractions. Further, few studies have reported the peak force, force (Fo) at specific time intervals and rate of force development (RFD). Therefore, the aim of this study was to investigate the effects of dietary NO<sub>3</sub><sup>-</sup> on the aforementioned characteristics of the knee extensors.

## METHODS:

Using double-blind, randomised, crossover design, 14 healthy participants completed two 5-day supplement period with either nitrate-rich (BR, ~800 mg/d) or nitrate-depleted beetroot (PLA) juice consumed. After each period, isometric knee extensor force was recorded during three maximal efforts interspersed with 20 s passive recovery. For the analysis, the raw data was inserted into a custom-spread sheet to determine maximal voluntary contraction (MVC), Fo at 50, 100, 150 and 200 ms, and RFD ( $\Delta\text{Force}/\Delta\text{time}$ ). Data was analysed using effect sizes and 95% confidence intervals. These were supplemented with magnitude-based descriptors using a post-only-crossover spreadsheet (2).

## RESULTS:

The magnitude of difference in MVC (BR,  $983 \pm 446$  N, vs PLA,  $944 \pm 420$  N) and Fo at 50 ms and RFD at 50 ms between BR and PLA was trivial (ES = 0.07 to 0.08) and considered unclear to most likely trivial. There was a small beneficial effect of BR on Fo at 100, 150 and 200 ms (ES = 0.28 – 0.35), with these findings considered possibly to likely positive. Similarly, RFD at 100, 150 and 200 ms was possibly to likely higher after BR supplementation with effect sizes considered small (ES = 0.28 – 0.35).

## CONCLUSION:

The results of this study revealed that short-term BR supplementation has no beneficial effect on MVC and Fo at 50 ms and RFD at 50 ms. Whilst results for the MVC agreed with previous research, those for Fo at 50 ms and RFD at 50 ms do not (3). Our results do, however, indicate that BR supplementation is beneficial for contraction of knee extensors at 100-200 ms. Such findings may have important implications for sporting actions that involved knee extensors and are executed within 100-200 ms.

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## EFFECTS OF BEETROOT JUICE INGESTION ON PHYSICAL PERFORMANCE AND MATCH-PLAY DEMANDS IN ELITE FEMALE FIELD HOCKEY PLAYERS

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## INTRODUCTION:

Beetroot juice (BJ) is a commonly used ergogenic aid that contains high levels of inorganic nitrate (NO<sub>3</sub><sup>-</sup>) and that its intake has proven effectiveness at increasing blood nitric oxide (NO) concentrations (1). The ingestion of BJ has good evidence of benefits in endurance sports (2) while team sports has been barely studied. In our knowledge, only a few studies have been developed in soccer/basketball (3,4) The present study was designed to compare the acute effects of BJ supplementation on physical performance and match-play demands in elite female field hockey players.

## METHODS:

Eleven well-trained female hockey players (22.78±5.12 years) participated during their preparatory period of their hockey season participated in the study. Participants were randomly divided into two groups undergoing a test battery with BJ (70mL) or placebo (PLAC) (70mL) in two separated days with one week between protocols. A neuromuscular test battery consisted in different test such as; countermovement jump (CMJ), isometric handgrip strength (IHS) and repeated sprint ability test (RSA). Afterwards a simulated hockey match play was realized and the data was recorded by Global Positioning System (GPS).

## RESULTS:

No significant improvements was observed in any physical parameters analysed comparing BJ versus PLAC ingestion, CMJ (p=0.776), IHS (p=0.829), RSA (p=0.466) and in any physical match demands measured by GPS (i.e., total distance covered, number of accelerations/decelerations, etc) (p= 0.063-0.941)

## CONCLUSION:

BJ acute supplementation did not produce any statistically significant improvement in physical performance or match-play demands in elite female field hockey players

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#### LONG-TERM OF IMIDAZOLE DIPEPTIDES SUPPLEMENTATION ATTENUATED EXERCISE-INDUCED HEPCIDIN ELEVATION

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##### INTRODUCTION:

Endurance exercise augments hepcidin (a liver derived-peptide hormone) secretion (Dominguez et al., 2018), leading to impairment of iron metabolism (Sangkhae and Nemeth, 2017). The augmented hepcidin level is suggested to be a factor for increasing the risk of iron deficiency in athletes (Peeling et al., 2008). Although several previous studies challenged whether antioxidant supplements (e.g., cranberry, pomegranate) attenuate exercise-induced hepcidin elevation, the attenuating effect has not been fully evident. In contrast, we have newly focused on the impact of imidazole dipeptides (antioxidant and buffering properties) supplementation on iron metabolism. The aim of the present study was to determine the effect of 28 days of oral imidazole dipeptides supplementation on hepcidin responses following an endurance exercise session.

##### METHODS:

Seventeen healthy males were assigned to one of two groups: (1) a group with consuming 1.5 g/day imidazole dipeptides [ITG, n=9; weight; 64.0 ± 1.6 kg, body fat; 12.7 ± 1.1%, maximal oxygen uptake (VO<sub>2</sub>max) ; 48.4 ± 1.2 ml/kg/min] or (2) a group with consuming 1.5 g/day placebo [PLA, n=8; weight; 67.3 ± 2.6 kg, body fat; 15.9 ± 1.7%, VO<sub>2</sub>max; 48.3 ± 1.7 ml/kg/min]. Participants had consumed imidazole dipeptides or placebo supplements daily for 28 days. Before and after supplementation period, they conducted 80 min of treadmill running at 70% of VO<sub>2</sub>max to evaluate exercise-induced hepcidin elevation, muscle damage and inflammatory responses. Significance was set at p < 0.05.

##### RESULTS:

Baseline serum ferritin level did not differ significantly between before and after supplementation period in either ITG (p = 0.08) or PLA (p = 0.96). Serum myoglobin levels (indirect muscle damage marker in blood) were significantly increased after exercise in both groups (p < 0.05), but there was no significant difference between before and after supplementation period. Serum iron levels significantly increased after exercise (p < 0.05), while serum haptoglobin (indirect of hemolysis) levels decreased after exercise in both groups (p < 0.05). However, no significant difference for these variables was observed between before and after supplementation. Serum hepcidin levels were significantly elevated 3h after exercise in both groups (before; 20.3 ± 5.9 to 38.7 ± 8.8 in ITG, 19.8 ± 13.5 to 47.0 ± 15.1 in PLA, after; 13.4 ± 2.2 to 22.9 ± 3.9 in ITG, 14.7 ± 2.7 to 30.4 ± 7.1 ng/mL in PLA, p < 0.05). In ITG, integrated area under the curve (AUC) for hepcidin levels during exercise and 3h of post-exercise was significantly lower in after supplementation period (1859 ± 484 vs. 648 ± 146 ng/mL · 260min, p = 0.02). In contrast, no significant difference for AUC was observed in PLA (2545 ± 976 vs. 1385 ± 521 ng/mL · 260min, p = 0.16).

##### CONCLUSION:

Long-term (28 days) of imidazole dipeptides supplementation attenuated hepcidin elevation following endurance exercise session.

#### FRAGMENTED DOSING OF BETA-ALANINE INDUCES A BODY WEIGHT-INDEPENDENT PHARMACOKINETIC RESPONSE.

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##### INTRODUCTION:

Athletes do not attain the same amount of augmentation in performance when taking ergogenic food supplements (CV% = 97%). The current (fixed and weight-relative) dosing strategies being used for beta-alanine are lacking in inducing a homogenous plasma response. Body weight accounts for 30% of the variation and ranges greatly in studies using beta-alanine. The plasma response needs to be homogenous in order to avoid favouring or impairing a certain weight group in supplementation. This study investigates whether a new (fragmented) dosing strategy results in a more homogenous plasma response in an anthropometric diverse sample, compared with the commonly used fixed and a weight-relative dose.

##### METHODS:

An anthropometric diverse sample (n = 20; body weight = 80 ± 24 kg; range = 49-138 kg) ingested a fixed dose (1600 mg), a weight-relative dose (20 mg/kg BW) and a fragmented dose (800 mg + 10 mg/kg BW) of beta-alanine on three separate occasions, after a standardized breakfast. Blood samples were taken before and at 7 time points (up to 3h30) after beta-alanine ingestion. Plasma beta-alanine at each time point was quantified using HPLC-fluorescence. A pharmacokinetic analysis was carried out, measuring the incremental Area Under the Curve (iAUC). The iAUC represents the total amount of beta-alanine in plasma over time.

##### RESULTS:

The variation coefficient (CV%) of the iAUC seemed smaller with the fragmented dose (26%), compared to the fixed (33%) and weight-relative dose (31%). The fixed dose showed a negative correlation between iAUC and body weight (r = -0.684, p = 0.001), meaning light subjects obtained a higher iAUC compared to heavier subjects. The weight-relative dose showed a positive correlation (r = 0.527; p = 0.017), meaning heavy subjects obtained a higher iAUC compared to lighter subjects. For the fragmented dose, body weight was not correlated with the iAUC (r = -0.168, p = 0.478).

##### CONCLUSION:

Since the effect of body weight on the iAUC is eliminated and the plasma response is more homogenous, the current study shows that a fragmented dose is an improvement over the commonly used fixed and weight-relative dose for beta-alanine. This dosing strategy could be used by future research to further decrease the variation in the dosing of beta-alanine, as well as in practice to avoid systematically favouring or impairing a certain weight group. Similar concerns regarding dosing strategy can potentially be taken towards other food supplements as well.

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## COMPARISON OF 3HMB AND 3HIB PRODUCTIONS BETWEEN THE RESISTANCE AND ENDURANCE EXERCISES WITH BCAA INGESTION

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### INTRODUCTION:

Branched-chain amino acids (BCAAs) are utilized in the skeletal muscles for energy production in endurance exercise. In BCAA catabolism, 3-hydroxyisobutyrate (3HIB) and 3-hydroxy-3-methylbutyrate (3HMB) are produced in the skeletal muscles as an intermediate of valine and a byproduct of leucine. We previously reported that 3HIB can be detected in the circulating fluid depending on the amount of endurance exercise, and 3HMB has been widely known to play a role of muscle protein synthesis enhancer in resistance exercise. This study aimed to compare the 3HIB and 3HMB levels in serum between the endurance and the eccentric resistance exercises in humans.

### METHODS:

In the endurance exercise, 14 subjects per group were supplemented with BCAA (3.2g in a granule) or placebo before a full-marathon race. In the eccentric resistance exercise, 5 subjects per group were repeatedly supplemented with BCAA (3.2g in a granule) or placebo with every meal for 3 days before experiment, and then, were loaded at sitting position with elbow extension lowering dumbbell of 90% participant's maximal voluntary isometric force from 90° flex to full extension taken over 5 sec in 6 sets of 5 repetitions. In both exercise experiments, serum was collected before the supplementation, immediately after, and a day after the exercises. Serum 3HIB and 3HMB concentrations were simultaneously quantified with a high-sensitivity LC-MS/MS system.

### RESULTS:

Immediately after the marathon race, both 3HIB and 3HMB concentrations in serum increased significantly compared to those in the before exercise, and both levels were significantly higher in the BCAA-supplemented group than in the placebo-supplemented group. Both increased levels recovered to each basal levels the next day. In the eccentric resistance exercise, serum 3HMB concentration increased significantly immediately after the immediately exercise only in the BCAA group compared to that in the before exercise and recovered to the basal level the next day. On the other hand, serum 3HIB concentration was no change in both groups by the resistance exercise.

### CONCLUSION:

The present study confirmed that both 3HIB and 3HMB were produced by endurance exercise, and the productions were further increased by the BCAA supplementation before the exercise. On the other hand, the production of 3HMB only was increased by the resistance exercise, and further emphasized by BCAA supplementation. These results showed that both 3HIB and 3HMB are metabolized by endurance exercise as results of the increase of BCAA utilization in the skeletal muscles, and the only 3HMB production from leucine is activated by resistant exercise. Thus, pre-exercise BCAA supplementation is effective for energy production from BCAA in muscles during endurance exercise and protein synthesis by 3HMB during resistance exercise.

## OP-PN06 Nutrition: Gut microbiota

### GUT MICROBIOTA OF ELITE FEMALE FOOTBALL PLAYERS DURING CONGESTED FIXTURES

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### INTRODUCTION:

Gut microbiota in athletes is a current hot topic. Athletes seem to have greater microbial diversity compared with sedentary individuals, which is a hallmark of gut health and stability and supports the positive link between exercise and metabolic health. Nevertheless, research in this field, namely with elite athletes, is still scarce, and little information exists regarding football players, either male or female. Thus, the aim of the present study was to characterize the gut microbiota of elite female football players. Also, changes in gut microbiota during a congested fixture has been investigated.

### METHODS:

Twenty-one elite female football players (age:  $24.3 \pm 3.4$  years) from the Portuguese National Team participated in the study. The study was conducted during the Algarve Cup 2019, over ten days, encompassing 3 official matches and 7 training sessions. Faecal samples were collected on the day prior to the beginning of the training camp (baseline) and during the last day of the tournament (final). Gut microbiota composition was analysed by sequencing the 16S rRNA gene. Data are presented as percentages or as mean  $\pm$  SD. Statistical comparisons were performed using paired Student's t-test (IBM SPSS 26).

### RESULTS:

At baseline, elite female players presented a Shannon diversity index of  $2.5 \pm 0.2$  with  $8.9 \pm 2.3$  phyla and  $18.9 \pm 4.2$  classes identified. The Firmicutes/Bacteroidetes ratio was  $2.4 \pm 1.3$ . No significant differences were found for any of these diversity and richness indices, nor for the Firmicutes/Bacteroidetes ratio between the two timepoints ( $p > 0.05$ ).

The most predominant genus in the gut microbiota of elite female players, at baseline ( $n=21$ ), was Faecalibacterium (in 13 samples), Prevotella (in 5 samples), Bacteroides (in 2 samples), and Roseburia (in 1 sample). In addition, the mean relative abundance of the most prevalent genus in all samples was  $29.5 \pm 10.2\%$  for Faecalibacterium,  $14.9 \pm 7.1\%$  for Collinsella,  $13.3 \pm 8.3\%$  for Bacteroides, and  $10.4 \pm 15.1\%$  for Prevotella. The relative abundance of most genera did not change during the congested fixture period except for Collinsella that was significantly reduced ( $p < 0.05$ ) at the end of the tournament when compared to the baseline ( $-4.2 \pm 6.6\%$ ).

### CONCLUSION:

The results of the present investigation suggest that Faecalibacterium is the most predominant enterotype in the gut microbiota of elite female football players. Faecalibacterium has been previously reported to be higher in active women in comparison to sedentary women and positively associated with the muscular mass index. Our results also show that congested fixtures might change the gut microbiota profile, mainly for Collinsella, but these changes might be player-dependent. Such a high prevalence of this genus has not been previously reported in the field of sports, and we hypothesized that it could be related to the specific characteristics of these athletes (females, football players or their diet).

## CORRELATION BETWEEN PHYSICAL CHARACTERISTICS AND COMPOSITION OF GUT MICROBIOTA IN MARATHON RUNNERS

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### INTRODUCTION:

Completely functional intestines and colon ensure an adequate supply of nutrients. Recent research suggests that the gut microbiota supports intestinal function. Moreover, the gut microbiota has been studied extensively for health promotion and exercise performance. Endurance runners routinely perform long-term endurance training. In particular, several days prior to a race, marathon runners start avoiding dietary fiber and indigestible starch and increase carbohydrate intake to store energy in skeletal muscles in preparation for the marathon. However, this diet may reduce microbial diversity and compromise the microbiome of the athlete's gut. In this study, we aimed to investigate the correlation between the components of microbiota and physical characteristics of marathon runners.

### METHODS:

We enrolled thirteen Japanese female elite-marathon runners (mean age,  $25.3 \pm 4.8$  years; maximal oxygen consumption,  $65.5 \pm 4.1$  mL/kg/min; percentage of body fat,  $13.2 \pm 1.2$  %; body mass index,  $18.1 \pm 0.8$  kg/m<sup>2</sup>). A stool sample was obtained from each athlete for gut microbiota analysis. We classified the gut microbiota using terminal restriction fragment length polymorphism analysis. The constituent bacteria were classified into 28 operational taxonomic units (OTCs) by Techno Suruga Laboratory Co., Ltd. In addition, the 16S rDNA in these samples were analysed by next-generation sequencing.

### RESULTS:

Each athlete had a different gut microbiota. Furthermore, the microbiota of six athletes revealed the presence of *Prevotella* spp., which is more common in individuals living the temperate Southeast Asian regions. No correlations were established between body mass index ( $R^2 = 0.01217$ ) and the percentage of body fat ( $R^2 = 0.02741$ ) with Bacteroidetes/Firmicutes ratio. However, results in this study unexpectedly suggest that the obesity-associated intestinal microbiota in female elite-marathon runners is characterised by a higher Bacteroidetes/Firmicutes ratio.

### CONCLUSION:

All the runners had a different gut microbiota. Interestingly, 6 out of 13 athletes possessed the *Prevotella* spp., which is more common in the temperate Southeast Asian regions. Long-distance runners who competed regularly were also more likely to possess the *Prevotella* spp. Moreover, the obesity-associated intestinal microbiota in elite-marathon runners was also found to have a higher Bacteroidetes/Firmicutes ratio. We hypothesise that this is a form of physiological adaptation to allow a longer period of glycogen consumption of skeletal muscle in long-distance training. These results suggest that marathon runners need to maintain intestinal bacteria that create an energy-efficient body for long hours of running. The results of this research are potentially useful for the design of the diet and physical conditioning for long-distance athletes.

## FACTORS INFLUENCING ATHLETES' FOOD CHOICES AND AVAILABILITY OF NUTRITION LABELLING AT EUROPEAN ATHLETICS CHAMPIONSHIPS

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### INTRODUCTION:

Over the years, athletes have been increasingly valuing the nutritional aspects of meals during the competition, hence the nutrient composition is among the most dictating factors for their food choice. However, the existing information on the athletes' opinion about the catering service and availability of dietary and nutritional information during competition is still limited. Therefore, and due to the relevance of this topic and the benefits it could bring to athletes, namely choosing food according to their dietary and nutritional needs and requirements, we studied the factors influencing athletes' food choices and their opinion about nutrition labelling during the 2019 European Athletics U20 and U23 Championships.

### METHODS:

All athletes  $\geq 18$  years competing in the 2019 European Athletics U20 and U23 Championships who had meals in the team restaurants were potentially eligible to participate in this study. Written informed consent was obtained from all the athletes who agreed to participate in the study. During meal time in the team restaurants, athletes fulfilled a self-administrated questionnaire regarding the factors influencing their food choices as well as their opinion about nutritional labelling. Data are expressed as percentages or as mean $\pm$ SD.

### RESULTS:

A total of 339 athletes (19.6 $\pm$ 1.3yrs, 57.2% males) from 35 countries correctly completed the questionnaire. The majority of athletes reported that their experience in the team restaurants matched (42.5%) or exceeded (38.8%) their expectation and, when asked about their overall experience regarding this topic, 90.0% rated it as positive ( $\geq 6$  on a scale from 1 to 10). The most important/very important factors influencing athletes' food choice were the time of the day (78.3%), nutritional composition (73.6%), temperature (71.5%), smell (69.5%), stage of the competition (69.0%), and visual appearance (66.2%). Although the nutritional composition of meals was one of the major factors influencing food choice during an international competition, only 49.1% of the athletes knew what a nutrition label is. Among those, 71.9% would like to have nutritional information regarding the meals provided in future championships, and 72.5% consider that the nutrition label would help them make better choices. The most important/very important elements that athletes reported to be relevant on a nutrition label were protein (84.8%), carbohydrates (83.6%), sugar (80.4%), energy (79.1%), fat (77.7%), and list of ingredients (75.3%).

### CONCLUSION:

Our results show that athletes seem to be very interested in the nutritional composition of the meals provided during European Athletics Championships and that the provision of a nutrition label in future Championships with the list of ingredients and the total amount of energy and macronutrients would be of great importance.

**OP-PN07 Molecular biology and biochemistry****SERUM CONCENTRATIONS OF FORMATION (PINP) AND RESORPTION (CTX) BONE TURNOVER MARKERS IN ASSOCIATION WITH VITAMIN D STATUS IN PROFESSIONAL ATHLETES**

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**INTRODUCTION:**

Biochemical markers of bone turnover reflect the cellular activity related to the bone formation and bone resorption, and can be useful in understanding the effects of physical activity on bone metabolism specially in such specific populations like professional athletes. The aim of this study was to evaluate the impact of the Vitamin D status on the serum of formation (PINP) and resorption (CTX) bone turnover markers concentrations during upper and lower body high intensity exercises.

**METHODS:**

Fourteen elite male artistic gymnasts (EAG) aged 20.6±3.3 years and 14 physically active men (PAM) aged 19.9±1.0 years performed lower and upper body 30s Wingate Tests. Blood for biochemical research was collected three times on the day of each test (immediately before and up to 5 and 30 minutes after Wingate Test completion) CTX and PIMP was measured by IDS-iSYS Immunodiagnostic Systems, Tyne and Wear, UK. Analyzes of vitamin D active metabolite, 25-hydroxy D3 (25OHD2), and 25-hydroxy D3 (25OHD3), as a total concentration of serum 25-hydroxyvitamin D (25(OH)D) was analysed using commercially available Total 25OH Vitamin D ELISA kits.

**RESULTS:**

Adult gymnasts had significantly lower vitamin D concentration comparing to physically active men. Serum concentrations of formation (PIMP) and resorption (CTX) bone turnover markers shows reverse trends in professional athlete. Vitamin D status is associated with bone formation markers and shows relationship with procalcitonin status. For the WanT results in both groups there were significantly higher values after lower body exercise. Absolute peak power differences between means ranged from 139.6 W in elite male artistic gymnasts (EAG) and 234.9 W in physically active men (PAM) ( $p < 0.01$ ). The range for absolute mean power was from 107 W in EAG to 190.7 W in PAM ( $p < 0.01$ ), 1.9 W/kg to 3.2 W/kg ( $p < 0.01$ ) for relative peak power, and 1.6 W/kg and 2.7 W/kg ( $p < 0.01$ ) for relative mean power. Differences between all analysed parameters were higher for the PAM group.

**CONCLUSION:**

Long-term gymnastic training causes specific adaptations in bone metabolism that are associated with vitamin D status.

**THE ROLE OF WHOLE-BODY VIBRATION ON BED REST MODEL-INDUCED SKELETAL MUSCLE ATROPHY AND FIBER TYPE COMPOSITION**

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**INTRODUCTION:**

Muscle disuse where mechanical load or neural activation is lost or reduced due to limb immobilization, long-term bed rest, and physical inactivity results in skeletal muscle atrophy. Although atrophy is a significant clinical problem, there are no known therapeutic interventions. Resistance exercise is a recommended application of maintaining muscle mass; however, not every individual can handle this exercise intensity after long-term bed rest, operation, or injury. The use of whole-body vibration (WBV) to elevate the muscle functions has gained popularity in recent years. Besides, WBV could improve muscle functions in a manner similar to that of traditional resistance training even more safely and conveniently. The molecular mechanisms of the effect of WBV on skeletal muscle are under investigation. Our study was designed to test the hypothesis that WBV prevents 28 days of disuse-induced muscle atrophy.

**METHODS:**

Thirty-two Wistar rats assigned one of the four groups: (n=8/group): 1- Control (C), 2- WBV (V), 3- Immobilization (I), and 4- WBV application during immobilization (IV). Immobilization has been applied by a cage volume reduction model (12x12x8cm) designed to restrict their locomotion movements during the 28 days. Whole-body vibration was applied as 30min/day at a frequency of 45 Hz, with an amplitude of 3mm during 28 days. At the end of the experimental protocol, grip strengths were measured, and soleus muscle isolated to investigate muscle fiber cross-sectional area and fiber type composition, myosin phenotype, selected molecules involved in protein synthesis, and degradation pathway using immunohistochemistry, SDS-PAGE, Western Blot.

**RESULTS:**

Grip strength was decreased in the immobilization group (C vs. I;  $p < 0.05$ ), and whole-body vibration has prevented this decrease (C vs. IV group;  $p > 0.05$ ). Soleus/body weight ratio was lower in group I (C vs. I;  $p < 0.05$ ) and, the WBV application has maintained soleus muscle mass (IV vs. I,  $p < 0.05$ ). Immobilization resulted in a decrease in type I and an increase in type IIa MHC isoforms (C vs. I;  $p < 0.05$ ), and whole-body vibration prevented this shift (C vs. 28 IV;  $p > 0.05$ ). However, WBV has resulted in a decrease in the number of type IIa fibers (C vs. V;  $p < 0.05$ ); WBV did not affect on the immobilization induced increase in the number of type IIa fiber (both I and IV groups vs. C;  $p < 0.05$ ). Protein levels of p-Akt have significantly reduced only in the immobilization group (I vs. C;  $p < 0.05$ ). Besides, MuRF1 ( $p < 0.05$ ), p-4EBP1 ( $p < 0.05$ ), and p-Smad2 ( $p < 0.05$ ) levels decreased in the V group compared to the C group.

**CONCLUSION:**

These results have shown that WBV application during 28 days of immobilization might prevent disuse-induced muscle mass and strength loss and atrophy by regulating the molecules in both protein synthesis and degradation pathway.

**THE INFLUENCE OF PHYSICAL ACTIVITY ON QUADRICEPS MUSCLE PERFORMANCE AND BIOLOGICAL CHARACTERISTICS OF VERY OLD ADULTS**

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**INTRODUCTION:**

The influence of physical activity (PA) on skeletal muscle performance in very old men and women (>80 yr) remains understudied. Yet, PA could influence muscle phenotype, capillarization and enzymes activity in ageing, and could be related to differences in muscle performance. The present study aimed to evaluate how PA influences knee extensors (KE) performance (i.e. isometric strength and fatigability) in healthy very old men and women. Muscle structural, microvascular and metabolic properties were further assessed using muscle biopsy in the vastus lateralis (VL) muscle.

**METHODS:**

Thirty very old adults (82±1 yr, 15 women) performed an isometric quadriceps intermittent fatigue (QIF) test for the assessment of KE maximal force, fatigability and total work (index of absolute performance at the QIF test). Muscle biopsies from the VL were collected to assess muscle fibers type and morphology (myosin heavy chain isoform immunolabeling), microvasculature (capillary density and tortuosity, CD31 labeling) and enzymes activity (by spectrometry). Correlation analyses were used to investigate the relationships between KE performance, PA (steps.day<sup>-1</sup>, actimetry) and biological data for each sex separately. Principal component analysis (PCA) was performed to detect the main components explaining variability between sexes.

**RESULTS:**

All participants were considered as active (men: 8841±2042 steps.day<sup>-1</sup>; women: 9312±2089 steps.day<sup>-1</sup>, P=0.53). Men showed greater maximal KE force and total work at the QIF test than women. Total work was correlated with PA level only for women (R=0.73, P=0.011). Fatigability and total work were not correlated to biological measurements for both men and women. PCA evidenced that cross-sectional area and capillarization of type I and IIA muscle fibers and oxidative enzymes activity explained most of the histological variability between sexes (44%). The component derived from these variables was lower in women than men and correlated with KE maximal force in this group (R=0.67, P=0.017).

**CONCLUSION:**

PA level positively influenced the capacity of very old women to perform a fatiguing test, but not maximal force production capacity of the KE. However, stronger women possessed greater type I and IIA fibers surface area, capillarization and oxidative enzymes capacity. PA level of very old men was not correlated to muscle performance. We suggest that very old women could be at higher risk of autonomy loss and would benefit from increasing their PA level by combining walking and reconditioning exercises.

**PHYSICAL ACTIVITY, PHYSICAL FITNESS AND TELOMERE LENGTH AND TELOMERASE: A SYSTEMATIC REVIEW.**

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**INTRODUCTION:**

Telomere length and telomerase are currently well known biomarkers of ageing. Telomeres protect against DNA degradation, recombination and chromosomal instability. Telomere length decreases in each cell division, resulting in cellular senescence when they reach a critical size. Furthermore, telomerase acts as a solution to combat the end replication problem through lengthening of telomeres. Although it is known that telomere shortening can be accelerated by cancer, diabetes, cardiovascular diseases or psychological stress, it remains unclear the association between physical activity (PA), physical fitness (PF), and telomere length or telomerase. Therefore, the aim of this review is to analyze and summarize any scientific evidence regarding to PA, PF and telomere length and telomerase expression.

**METHODS:**

A systematic search of PubMed and Web of Sciences databases were performed from database inception to April 2020 (PROSPERO with number CRD42020187315), using the terms physical activity, fitness and telomere length and telomerase expression. All titles and abstracts were screened. Studies that could meet inclusion criteria (i.e., articles that search an association between levels of PA or PF and telomere length or/and telomerase) were included. A narrative synthesis of the studies found were conducted.

**RESULTS:**

: Out of 3.122 articles that were screened initially, a total of 98 articles (n=78 in healthy population, and n= 20 in people with any pathology) were finally included. More than half of the articles (67%) included were cross-sectional studies, while 14 were longitudinal and 21 intervention studies. Among the selected studies, 74 evaluated the association of PA and telomere length: 32 showed a positive association, 26 did not find any statistically significant result, 12 reported inconsistent findings, 2 demonstrated a negative association and 2 identified an inverted "U" relationship. Furthermore, 30 studies assessed the relationship between fitness and telomere length: 14 found a positive association in at least one parameter related to fitness, 12 did not report any statistically significant result and 4 revealed inconsistent findings. Regarding telomerase, only 10 studies evaluated its association with PA: 5 indicated a positive relationship, 3 did not show any statistically significant result and 2 found discordant findings. No articles that studied the relationship between fitness and telomerase were identified.

**CONCLUSION:**

Overall, our findings showed that there is a trend to establishing a positive association between PA or PF and telomere length, and also between PA and telomerase. Due to the methodological variety it is challenging to determine the effect of PA or PF in telomere length and telomerase from previous studies.

Thus, further studies are required to achieve this task and future studies that analyze the association between physical fitness and telomerase are needed.

**HIGH INTENSITY INTERVAL MULTICOMPONENT TRAINING IMPROVES PHYSICAL FUNCTION AND PROTECTS AGAINST FRAILITY IN GLUCOSE-6-PHOSPHATE DEHYDROGENASE OVEREXPRESSION MICE**

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**INTRODUCTION:**

Glucose-6-phosphate dehydrogenase (G6PD) regulates the NADPH levels, protecting the cell against oxidative damage. Mice that overexpress G6PD have higher levels of NADPH, lower levels of oxidative damage, and better protection from age-associated functional decline. High intensity interval training (HIIT) is a powerful short-term stimulus to induce many of the physical adaptations typically associated with traditional, moderate-intensity long duration continuous training. Therefore, our primary purpose was to study whether high intensity interval multicomponent training would induce positive adaptations in old mice.

**METHODS:**

Twenty-six G6PD-Tg male mice (23 months old) were randomly divided in two groups: sedentary (n=9) and trained (n=17). The exercise group followed a multicomponent training that included motor coordination, progressive resistance, and high intensity interval endurance exercises. The animals were trained 5 days a week (a total of 110 minutes) for ten weeks. All mice were evaluated before and after the intervention for different functional parameters. Independent and paired t-tests were conducted to compare means between and within groups before and after the intervention. All data are expressed as mean (standard error of mean). A value of  $p < 0.05$  was considered statistically significant.

**RESULTS:**

Compared to sedentary mice, trained mice showed an improvement in: (i) motor coordination evaluated through the rotarod test [114.7 (7.4) vs 163.3 (13.1) seconds,  $p < 0.05$ ]; (ii) grip strength [4.4 (0.1) vs 5.7 (0.2) grams of force / grams of body mass,  $p < 0.0001$ ]; (iii) maximal strength [95.6 (4.5) vs 206.9 (4.8) % of body mass,  $p < 0.0001$ ]; (iv) and endurance test [1501 (265.2) vs 2679 (279.7) meters,  $p < 0.05$ ]. In addition, we found a decrease in the percentage in frail mice, measured through the "Valencia Score" for frailty (3), in the trained animals when compared to the sedentary ones (7 vs 45 %,  $p < 0.0001$ ).

**CONCLUSION:**

Our results show that high intensity interval multicomponent training improves physical function and prevents, or even reverses, frailty in G6PD-Tg mice when compared to the sedentary group.

### **FOKI AND TAQI POLYMORPHISMS IN THE VITAMIN D RECEPTOR GENE AFFECT MUSCLE STRENGTH AND FUNCTION OF KOSOVAN ADULTS**

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**INTRODUCTION:**

Vitamin D status is associated with muscle strength and functional performance [1]. Recently, we have summarized genetic variants within vitamin D pathway-related genes that were associated with vitamin D level and/or muscle traits in a systematic review [2]. This study aims to prove empirically whether frequently reported single nucleotide polymorphisms (SNPs) across the vitamin D receptor (VDR) and the vitamin D binding protein (GC) would have a direct genetic impact on several muscle traits in Kosovan adults.

**METHODS:**

In this cross-sectional study, genomic DNA was isolated from saliva samples of 300 community-dwelling adults living in Kosovo (52.8% women; age:  $66.2 \pm 9.8$  yrs; BMI:  $29.4 \pm 4.7$  kg/m<sup>2</sup>). Genotyping of three candidate SNPs located in the VDR gene (rs7975232 [ApaI], rs731236 [TaqI] and rs2228570 [FokI]) and of two in the GC gene (rs4588 and rs2282679) was performed using commercial available genotyping assays for real time PCR (Applied Biosystems). Anthropometric data (BMI, body composition), physical performance (30-s chair stand, 30-s arm curl (AC), gait speed, timed up and go (TUG), and 6 minutes walking tests), handgrip strength (HG) and isokinetic peak torque of knee extensors were determined. Hardy-Weinberg equilibrium was calculated using Chi2 test. Due to violations in normal distribution, differences in muscle traits between the genotypes were analyzed using Kruskal-Wallis H followed by Bonferroni-corrected Mann-Whitney post hoc tests. Dominant and recessive models were compared by Mann-Whitney test.

**RESULTS:**

Genotype distributions for the selected SNPs were in Hardy-Weinberg equilibrium, except for the FokI ( $\chi^2 = 5.93$ ,  $p = 0.0149$ ). Significant differences between FokI genotypes were found for TUG, relative HG, and AC tests (TUG:  $\chi^2(2) = 6.627$ ,  $p = 0.036$ ; relative HG:  $\chi^2(2) = 6.301$ ,  $p = 0.043$ ; AC:  $\chi^2(2) = 6.972$ ,  $p = 0.031$ ). Subjects homozygous for the minor allele (AA) were faster in TUG than AG+GG ( $p = 0.016$ ), but had a lower relative handgrip strength ( $p = 0.014$ ) and a tendency for worse results in AC test ( $p = 0.084$ ). In females, relative HG was different for TaqI genotypes ( $\chi^2(2) = 6.082$ ,  $p = 0.048$ ). All other tested genotypes did not affect muscle traits ( $p > 0.05$ ).

**CONCLUSION:**

From the five tested genotypes only FokI (initiator codon variant) and TaqI (synonymous variant) showed some associations to muscle traits, thereby confirming the hypothesis that genetic variants in vitamin D pathway-related genes have the potential to directly impact muscle traits. However, tests for upper body strength (HG, AC) were controversially affected by the FokI genotype than the TUG (lower body). Similar divergent results have been shown previously [3,4], but these findings warrant further mechanistic investigations.

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### **MOLECULAR MECHANISM OF THE EFFECT OF AEROBIC AND RESISTANCE EXERCISES ON THE REGULATION OF BDNF EXPRESSION IN THE BRAIN**

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**INTRODUCTION:**

Through regulating brain-derived neurotrophic factor (BDNF) expression, which is beneficial to cognition improvement, exercise plays a vital role in improving learning and memory. However, not all types of exercise could promote BDNF expression effectively. While aerobic exercise has been well studied and shown to improve BDNF expression, resistance exercise remains controversial in BDNF induction. The mechanism of this difference is unclear. Here, we compared the role of treadmill running and ladder climbing in BDNF induction in the brain and explored the underlying mechanism.

**METHODS:**

Male Sprague-Dawley rats were divided randomly into control (n=10), treadmill running (n=10), and ladder climbing (n=10) groups. After 8-week exercise, brain tissue was collected and tail vein blood was extracted. mRNA level and protein level of BDNF in the brain were measured through real time RT-PCR and Western Blot, respectively. Serum BDNF level was tested using ELISA kit from R&D. HDAC3 expression was tested by real time RT-PCR. Brain  $\beta$ -hydroxybutyrate level were measured using commercial kit from Sigma-Aldrich. Finally, we examined FNDC5 expression in the brain, and irisin level in the blood by ELISA kit from Phoenix Pharmaceuticals. Two-way ANOVA was applied to compare difference among distinct groups using SPSS software and  $p < 0.05$  was considered statistically significant.

RESULTS:

Significant increases of mRNA level and protein level of BDNF were present in treadmill running rats compared to control group, while little effect on BDNF expression was observed in the brain of ladder climbing rats, which further indicates the type of exercise influences differently BDNF expression. Moreover, elevated brain  $\beta$ -hydroxybutyrate level and reduced HDAC3 expression were found in the brain of treadmill running rats, while decreased  $\beta$ -hydroxybutyrate level, and unaltered HDAC3 expression were present in ladder climbing rats. Decrease in FNDC5 expression was only found in the brain of treadmill running rats, while unaltered serum irisin level was observed following both treadmill and climbing exercise compared to control group.

CONCLUSION:

Aerobic exercise outperforms resistance exercise in terms of induction of BDNF expression in the brain, which is of importance to improve learning and memory. Through increasing  $\beta$ -hydroxybutyrate level and inhibiting HDAC3, aerobic exercise could promote BDNF expression through epigenetic modification. This regulation pathway was not found in resistance exercise.

**THE HIGH-ENERGY PHOSPHATE TRANSFER BETWEEN SERCA AND MITOCHONDRIA IS MAINTAINED FOLLOWING ACUTE EXERCISE DESPITE INTRINSIC IMPAIRMENTS IN MITOCHONDRIAL ADP SENSITIVITY**

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INTRODUCTION:

Impaired calcium (Ca<sup>2+</sup>) release/uptake contributes to skeletal muscle fatigue, however the underlying mechanisms remain poorly understood. While a potential link between Ca<sup>2+</sup> homeostasis and energy production is high-energy phosphate cycling between sarco/endoplasmic reticulum Ca<sup>2+</sup> ATPase (SERCA) and mitochondria, this relationship remains unknown. During exercise, reductions in mitochondrial ADP responsiveness would result in an accumulation of cytosolic ADP and could limit ATP provision to SERCA, mechanisms which may be implicated in fatigue. Therefore, in the present study we examined the possibility of a high-energy phosphate cycling microdomain between SERCA and mitochondria, and if prolonged exercise would impair the interaction between these organelles.

METHODS:

Male C57Bl/6N mice remained sedentary (SED), performed an acute bout of treadmill running (EX, 90min, 15m/min, 5% grade), or were subject to an 8-week high fat diet (HFD). Mitochondrial ADP and Ca<sup>2+</sup> (SERCA-supported) respiration experiments were performed in permeabilized red gastrocnemius muscle fibers. Data are expressed as mean $\pm$ SD.

RESULTS:

We first established a technique to examine the interaction between SERCA and mitochondria by nucleotide transfer. To do so, we titrated Ca<sup>2+</sup> in the presence of ATP to stimulate SERCA-mediated ATP hydrolysis and create ADP to drive mitochondrial respiration. This revealed that maximal SERCA-supported respiration was ~25% of maximal oxidative capacity, while cyclopiiazonic acid, a SERCA-specific inhibitor, fully prevented Ca<sup>2+</sup>-mediated mitochondrial respiration. We then utilized this approach to determine the effects of exercise on coupling between SERCA and mitochondria. As acute exercise decreased mitochondrial ADP sensitivity ~30% (Km: 1002 $\pm$ 217 $\mu$ M ADP EX vs. 759 $\pm$ 186 $\mu$ M ADP SED, p<0.03), we reasoned that sensitivity to SERCA-mediated ADP provision would also be decreased. However, mitochondrial sensitivity to Ca<sup>2+</sup>-induced ADP supply from SERCA (Km: 146 $\pm$ 104nM Ca<sup>2+</sup> EX vs. 135 $\pm$ 72nM Ca<sup>2+</sup> SED, p=0.8), and maximal Ca<sup>2+</sup>-supported respiration, were not altered by exercise, suggesting a maintained microdomain between mitochondria and SERCA. While HFD also represents a situation of impaired mitochondrial ADP sensitivity (~35% lower vs. SED, p<0.01), in contrast to exercise, Ca<sup>2+</sup> sensitivity was decreased ~3-fold, indicating the crosstalk between SERCA and mitochondria can be altered.

CONCLUSION:

These data suggest impairments in mitochondrial ADP sensitivity following exercise are not associated with reductions in the ability of SERCA-derived ADP to stimulate mitochondrial respiration. As a result, this likely does not contribute to impairments in Ca<sup>2+</sup> homeostasis or exercise-induced skeletal muscle fatigue. Furthermore, this methodology can be applied to diverse situations of muscle use and disuse to understand the link between mitochondrial bioenergetics and Ca<sup>2+</sup> homeostasis.

**MEALWORMS ARE A VIABLE PROTEIN SOURCE TO INCREASE MUSCLE PROTEIN SYNTHESIS RATES AT REST AND FOLLOWING RESISTANCE-TYPE EXERCISE IN VIVO IN ACTIVE YOUNG MALES**

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INTRODUCTION:

Insects have recently been identified as a sustainable source of high-quality protein and may represent an alternative to conventional animal-based protein sources. So far, little is known about the postprandial protein handling of insect protein at rest or during recovery from exercise. Therefore, this study assessed the impact of ingesting mealworm protein vs milk protein on protein digestion and amino acid absorption kinetics, the subsequent postprandial stimulation of muscle protein synthesis rates, and the incorporation of dietary protein derived amino acids into de novo muscle protein both at rest and following exercise in vivo in humans.

METHODS:

In this double-blind randomized parallel-group trial, 24 healthy young males ingested 30 g specifically produced, intrinsically L-[1-13C]-phenylalanine and L-[1-13C]-leucine labeled, mealworm or milk protein following a single bout of unilateral resistance-type exercise. Primed continuous L-[ring-2H5]-phenylalanine, L-[ring-2H2]-tyrosine, and L-[1-13C]-leucine infusions were applied, with frequent collection of blood and muscle samples. The ingestion of intrinsically labeled mealworm or milk protein combined with intravenous stable isotope infusions allowed us to directly assess protein digestion and amino acid absorption kinetics, postprandial muscle protein synthesis rates, and the incorporation of dietary protein derived amino acids into de novo muscle protein both at rest and following exercise. Data were analyzed using repeated measures ANOVA with Time (basal vs postprandial) and Leg (exercise vs rest) as within-, and Drink (mealworm vs milk) as between-subjects factor. Data represent means $\pm$ SD.

RESULTS:

Plasma leucine and essential amino acid concentrations increased following protein ingestion (Time: P<0.05), with greater increases following milk vs mealworm protein ingestion (Time\*Drink: P<0.05). A total of 74 $\pm$ 7 and 77 $\pm$ 7 % of the mealworm and milk protein-derived

phenylalanine appeared in the circulation during the 5 h postprandial period, respectively, with no differences between drinks ( $P=0.26$ ). Greater increases in muscle protein synthesis rates were observed in the exercise vs rest leg (Time\*Leg:  $P<0.001$ ). Separate analyses showed that muscle protein synthesis rates based on the L-[ring-2H5]-phenylalanine increased following both mealworm and milk protein ingestion from  $0.025\pm 0.008$  to  $0.045\pm 0.017$  %/h and  $0.028\pm 0.010$  to  $0.056\pm 0.012$  %/h at rest, and from  $0.025\pm 0.012$  to  $0.059\pm 0.015$  %/h and  $0.026\pm 0.009$  to  $0.073\pm 0.020$  %/h following exercise, respectively (Time: both  $P<0.001$ ), with no differences between mealworm and milk (Time\*Drink: both  $P>0.05$ ).

#### CONCLUSION:

Ingestion of a meal like amount of mealworm protein is followed by rapid protein digestion and amino acid absorption and increases muscle protein synthesis rates both at rest and during recovery from exercise. The postprandial protein handling of mealworm protein does not differ when compared to the ingestion of the same amount of milk protein.

### EFFECT OF MCT1 T1470A POLYMORPHISM IN MAXIMAL LACTATE PRODUCTION: A PILOT STUDY

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#### INTRODUCTION:

Lactate can be transported through sarcolemma by MCT1 and MCT4 (1). Lactate transport by MCT1 could be modified by the T1470A SNP in the SLC16A1 gene (rs1049434), leading to differences in circulating blood lactate and lactate clearance among genotypes(2, 3). However, there is a lack of studies regarding its influence over lactate kinetic during an incremental effort. Thus, the purpose of this study was to analyze the influence of the SLC16A1 SNP on the lactate response in a maximal incremental test in males.

#### METHODS:

Sixteen trained males (24 years, 72.8kg and 1.765m) were divided in two groups based on their genetic profile (AA=9 and TT=7). Genotyping was done using real-time PCR. The incremental test was performed on a cycloergometer, starting at 75 W and increasing 35 W each 3 min, until exhaustion. Capillary blood lactate concentration was analysed using a lactate analyser (Lactate Plus, Germany) at rest, in the last thirty seconds of each step and at maximal effort. Unpaired Student's t-test was used to observe differences between genetic groups. Cohen's d was used to calculate the effect size. The whole sample was divided in two groups using the median based on the maximal lactate levels obtained. A chi-squared test was used to observe the genotype frequencies between lower group and higher group. Threshold values for ES were  $\geq 0.1$  (small),  $\geq 0.3$  (moderate),  $\geq 1.2$  (large), and  $\geq 2.0$  (very large). The level of significance was set at  $p \leq 0.05$ .

#### RESULTS:

The maximal lactate response of the AA group ( $12.3\pm 0.69$ ) was not significantly higher than the TT group ( $10.9\pm 0.67$ ) ( $p=0.185$ ) and the effect size Cohen's d was 0.74. The chi-squared test showed no significant difference in the frequencies between the lower and the higher group ( $p=0.131$ ). In addition, it was observed an odds ratio of 5 (95% CI: 0.584-42.797) for the TT subjects to be in the lower group compared with the AA participants.

#### CONCLUSION:

Our results indicate that the influence of the SLC16A1 T1470A SNP could not be relevant in maximal lactate levels during an incremental test. In a previous study, AA genotype had significantly lower levels of maximal lactate than T allele carriers. However, they performed a circuit weight training instead of a maximal incremental test (2). The lack of significant differences could be due to the lactate levels reached, which are high enough to saturate the MCT1 transporters and augment the importance of the diffusion component in total lactate transport. (4). Based on these results, the T1470A SNP in the SLC16A1 gene does not seem to have a significant influence over the maximal lactate response immediately after an incremental test.

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### EFFECTS OF POWER AND MULTI-COMPONENT TRAINING WITH ELASTIC RESISTANCE ON OXIDATIVE STRESS, PHYSICAL FUNCTION AND STRENGTH

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#### INTRODUCTION:

Human aging is characterized by decreases in muscle strength and physical function. One of the causes of these changes may be the cumulative effects of reactive oxygen species along with a decrease in endogenous antioxidants (Bouزيد, Hammouda, Matran, Robin, & Fabre, 2014). Understanding the effects of emerging training modalities such Multi-component training (MT) and Power training (PT) on the oxidative stress, physical function and strength is the primary objective of this study

#### METHODS:

51 sedentary OW (68.47  $\pm$  5.0 yrs.) were randomized into MT (n=15), PT (n=18) and Control groups (CG) (n=18). All exercise groups trained twice weekly for 20 weeks. MT group performed balance (static and dynamic), muscular endurance [2 exercises, 3-4 sets of 15 repetitions at 7-9 RPE (Colado et al., 2018)], aerobic, flexibility, and coordination exercises in each session. PT group performed 6 exercises (for upper and lower limbs), 3-4 sets of 10-12 repetitions, at a rate of perceived exertion (RPE) of 3-4 (very low) in the first repetition and no more than 6 in the last one (performing the concentric phase "as fast as possible"). Thus, a high velocity displacement of the resistance was guaranteed during all the repetitions. All the training groups used elastic variable resistance for training the muscle strength (elastic bands CLX). 8-hydroxy-2-deoxy Guanosine (8-OHdG), 8-isoprostane (F2 iso), superoxide dismutase (SOD), glutathione peroxidase (GPx), maximal strength of knee extensors (KE) at 60°/s and 180°/s and 5-repetition Sit-to-Stand test (5STS) were evaluated. Intention-to-treat analysis with repeated measures ANCOVA (3 group x 2 time) adjusting for age and baseline values was performed.

#### RESULTS:

Both training groups showed significant improvements ( $p<0.05$ ) by time in DNA damage (8-OHdG) (MT:-46.62%, PT: -58.93%), lipid oxidation (F2 iso) (MT:-30.72%, PT: -28.38%), and the antioxidant enzyme SOD (MT: +28.13%, PT: +20.42%). PT modality was the only one that



showed significant group x time interaction on 8-OHdG with CG. Significant differences between both training modalities and CG were found on SOD. Indeed, both training groups improved significantly the maximal strength of the KE muscles at two velocities (KE at 180°/s; MT: +9.11 and PT: +21.36 // KE at 60°/s; MT: +6.18 and PT: +3.03) and the 5STS (MT: -12.42 and PT: -25.47). There were significant differences between MT and PT for 5STS.

CONCLUSION:

PT and MT modalities using elastic variable resistance could be effective to improve oxidative stress, strength and physical function in older women in a short period of time, being the PT the strategy that produces the greatest adaptations. It's necessary to promote such training programs due to could be beneficial in the reduction of the oxidative stress and in the maintenance of the older adults independency.

### **PRESERVED CAPACITY FOR SATELLITE CELL PROLIFERATION, REGENERATION AND HYPERTROPHY IN THE SKELETAL MUSCLE OF HEALTHY ELDERLY MEN**

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INTRODUCTION:

Blunted muscle hypertrophy and impaired regeneration with aging have been partly attributed to myogenic progenitor cell (satellite cell (SC)) dysfunction. However, true muscle regeneration has not yet been studied in elderly individuals. Furthermore, muscle injury is a strong stimulus for SC-activation and proliferation and could therefore have long-term beneficial effects on the resistance training induced hypertrophy response.

METHODS:

To investigate this, muscle injury was induced by 200 electrically stimulated (ES) eccentric contractions of the vastus lateralis (VL) of one leg in 7 young (20-31 yrs) and 19 elderly men (60-73 yrs). This was followed by 13 weeks of resistance training (RT) for both legs to investigate capacity for hypertrophy and regeneration. Muscle biopsies were collected Pre and Post RT, and 9 days after ES, for immunohistochemistry and RT-PCR. Hypertrophy was assessed by MRI, DEXA and immunohistochemistry.

RESULTS:

Overall, surprisingly comparable responses were observed between young and elderly. 9 days after ES, myofibre necrosis was accompanied by a doubling in SCs (Pax7+,  $p < 0.05$ ), alongside substantial changes in expression of genes related to extracellular matrix, myogenesis, and innervation ( $p < 0.05$ ). After 13 weeks of resistance training, VL cross-sectional area had increased in both legs (~15%,  $p < 0.01$ ) and SCs/type II fibre had increased ~2-4 times more with ES+RT vs. RT alone ( $p < 0.001$ ).

CONCLUSION:

Together these novel findings demonstrate "youthful" regeneration and hypertrophy responses in human elderly muscle. Furthermore, boosting SC availability in healthy elderly men does not enhance the subsequent muscle hypertrophy response to RT.

### **EXERCISE-MIMICKING ELECTRIC PULSE STIMULATION INDUCES METABOLIC CHANGES IN MYOTUBES**

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INTRODUCTION:

Exercise-like electric pulse stimulation (EL-EPS) and thus contraction of the myotubes has been reported to mimic certain physiological responses of in vivo exercise [1]. A major benefit of the in vitro EL-EPS approach in exercise research is the exclusive examination of the contraction-induced changes in skeletal muscle metabolism without an interference of other organs or tissues. This enables the assessment of how myotube contractions affect energy metabolism, mitochondrial respiratory capacity and the metabolome both within the cells as well in the cell culture medium containing all the secreted molecules.

METHODS:

Long-term low frequency EL-EPS (24h, 2ms, 1Hz, 12V) was applied on C2C12 myotubes by placing the C-Dish carbon electrodes attached to the C-Pace 100 machine (Ionoptix Corporation). Next, A) oxygen consumption, B) changes in the metabolome and C) fatty acid oxidation were analysed. Shortly, routine and maximal oxygen consumption of the myotubes after EL-EPS were analysed by OROBOROS Instruments device using SUIT8. Samples for the metabolomic analysis of the myotubes and cell culture medium were collected as previously described [2]. The metabolites were assessed by nuclear magnetic resonance (NMR) and Chenomx software. For the analysis of the fatty acid oxidation, myotubes were acclimatized to oleate for 24h at day 4 post differentiation and the following day EL-EPS was conducted as above. The radioactive 3H-oleate was added for the last 2h of the 24h EL-EPS and the medium containing heavy water was collected and analysed by scintillation counter. Furthermore, western blot, enzyme-linked immunosorbent assay (ELISA) and enzyme activities were also used for protein analysis. All the experiments were conducted in serum free conditions.

RESULTS:

As a proof of a suitable and functional in vitro exercise model, the preliminary data demonstrated that the used EL-EPS protocol promoted the phosphorylation of AMP-activated protein kinase (AMPK) and acetyl-CoA carboxylase (ACC) in C2C12 myotubes accompanied by an increase in the citrate synthase and increasing trend in  $\beta$ -hydroxyacyl CoA-dehydrogenase activities. Fatty acid oxidation decreased after EL-EPS when typical high glucose (4.5g/l) cell culture medium was used. Preliminary secretome analysis of the EL-EPS cell culture medium suggest that the concentrations of interleukin 6 and lactate increased while glucose concentration decreased. No changes in the respiratory capacity between the EL-EPS stimulated and unstimulated myotubes were observed at this time point.

CONCLUSION:

We were able to reproduce many of the required features of a successful in vitro exercise model as listed previously [1], such as elevated myokine release and activated signalling pathways enhancing aerobic metabolism. Furthermore, when glucose is not the limiting factor, contracting myotubes seem to strongly rely on carbohydrate metabolism.

References: 1. Nikolić et al. (2017) , 2. Kostidis et al. (2017)

**SEX DIFFERENCES IN MUSCLE FUNCTION AND MYOCELLULAR RESPONSE TO A STRENUOUS MILITARY FIELD EXERCISE**

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**INTRODUCTION:**

Exposure of extreme stress during military operations can affect the soldiers' operability for several weeks (1). However, the myocellular response to arduous military operations and the molecular regulation in the recovery phase has been less investigated. Furthermore, it is not known whether there are sex differences to such extreme stress. Therefore, the objective of this study was to investigate the impact of a strenuous military field exercise on muscle function and regulators of autophagy and muscle damage, and to identify possible sex differences in the acute response and in the recovery phase.

**METHODS:**

Soldiers (Female "f"=8, Male "m"=10) from the Norwegian Defence Cyber Academy conducted a 10 days long strenuous military field exercise. Leg extension strength was tested before (Pre), after (T1), one week after (T7) and two weeks after (T14) the exercise. Skeletal muscle biopsies were obtained from m. vastus lateralis at Pre, T1 and T7. Fractionated biopsies were analyzed for the following proteins by western blots: LC3b, Murf1,  $\alpha$ B-Crystallin, HSP70, and p62. Data was analyzed by a two-way ANOVA for sex differences, one-way ANOVA for time differences and by Pearson R for correlations.

**RESULTS:**

Leg extension strength was reduced by  $-9\pm 11\%$  for the group at T1 ( $p<0.05$ ) and was still reduced  $-8\pm 12\%$  at T14 ( $p<0.05$ ), with no sex differences. Cytosolic  $\alpha$ B-Crystallin-protein decreased  $-20\pm 12\%$  for the women at T1 ( $p<0.01$ ). Cytoskeletal HSP70-protein tended to increase  $80\% \pm 169\%$  for the group at T7 ( $p<0.1$ ). The %-change in maximal leg extension force correlated positively with changes in the cytosolic fraction of  $\alpha$ B-Crystallin-protein for the group and the sexes separately ( $r_{\text{group}}=0.29$ ,  $r_f=0.41$ ,  $r_m=0.31$ ,  $p<0.05$ ), and negatively with changes in the cytoskeletal fraction of HSP70-protein for the group and the women ( $r_{\text{group}}=-0.31$ ,  $r_f=-0.54$ ,  $p<0.05$ ). Cytoskeletal Murf1-protein increased  $89\% \pm 133\%$  for the group ( $p<0.05$ ) at T7. Membranous p62-protein increased  $39\% \pm 47\%$  for the group and  $31\% \pm 36\%$  for the men at T1 ( $p<0.05$ ). LC3b2/LC3b1-ratio increased  $39\% \pm 113\%$  for the group and  $64\% \pm 140\%$  for the men at T7 ( $p<0.05$ ). There was a tendency for sex difference in cytosolic HSP70-protein at T1, where men increased  $26\% \pm 30\%$  and women decreased  $-8\% \pm 26\%$ .

**CONCLUSION:**

These results indicate that a strenuous military field exercise leads to similar changes in protein catabolism for men and women, which last for at least one week. The reductions in leg extension strength was correlated with changes in proteins indicating increased damage in the cytoskeletal fracture of the muscle cells. There was a tendency for sex difference in the change in protein levels of cytosolic HSP70, but this was not related to any difference in reduction of maximal force. The results indicate that there may be sex differences in the myocellular response to a military field exercise, but further investigations are needed.

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**MODULATION OF SKELETAL MUSCLE NRF2 AND NFKB SIGNALING BY EXERCISE DURING EXTREME ENERGY DEFICIENCY IN HUMANS: ROLE IN MUSCLE CATABOLISM**

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**INTRODUCTION:**

Pro-inflammatory processes and oxidative stress interplay in obesity, which elevate the risk of disease and are associated with rapid losses of skeletal muscle (SM) mass. Upon elevated levels of oxidative stress, Nrf2 is activated to reduce ROS, while excessive ROS triggers NFkB signaling, a pro-catabolic transcription factor in animal models. Caloric restriction and exercise are effective strategies to mitigate obesity and both elicit upregulation of Nrf2 and NFkB signaling. However, no study has investigated the simultaneous interaction of both stimuli on human SM. Thus, we aimed to study the effect of different amounts of exercise during caloric restriction on the regulation of SM Nrf2 and the NFkB pathways and its potential role in the regulation of muscle mass.

**METHODS:**

Fifteen overweight and obese men were subjected to 4 days of caloric restriction (0.8g/kg BW/day of whey n=8 or sucrose n=7) and prolonged exercise (CRE) (45min of one-arm cranking and 8h walking/day). SM biopsies from both deltoid and one vastus lateralis were taken before (PRE), after CRE and following 3 days of control diet (isoenergetic) and reduced exercise (CD); and SM pSer40Nrf2, Keap1, SOD2, Catalase, NFkB p50 and NFkB p105 protein expression were analyzed (WB). Body composition was assessed by DEXA. Statistical analysis was performed with repeated measures ANOVA.

**RESULTS:**

After CRE the energy deficit was 5500 kcal/d, reducing fat-free mass ( $P<0.001$ ). Legs and trained arm lost proportionally less FFM than the untrained arm [ $57\%$  ( $P<0.05$ ) and  $29\%$  ( $P=0.05$ ), respectively]. The activating phosphorylation at Ser40 of Nrf2 increased in all muscles after CRE and even further after CD ( $p<0.05$ ), with a larger increase in arms than legs (extremity x time,  $p=0.05$ ). Keap1 (Nrf2 repressor) was reduced only in the legs after CRE (extremity x time,  $p=0.046$ ) and returned to basal at CD. Catalase increased in the arms (mean of both) after CRE ( $p=0.039$ ), while remaining unchanged in the legs. No significant changes were found in SOD2. The levels of NFkB p50 and p105 responded similarly, being increased after CRE and CD, but to a larger extent in arms than legs ( $p<0.05$ ). No significant changes were found due to the solution ingested.

**CONCLUSION:**

During an extreme energy deficit, there is an upregulation of the antioxidant system via Nrf2 in human skeletal muscle, which is enhanced by large amounts of contractile activity. The fact that Nrf2 activation was stimulated further in the legs likely permitted a lower expression of the antioxidant enzyme catalase. Furthermore, the increase in NFkB, a ROS-dependent transcription factor, was less marked in the legs, which supports the antioxidant effect exerted by exercise in the legs. The lower NFkB signaling in the legs (a potent catabolic transcription factor) combined with a lower loss of muscle mass could indicate that high-volume low-intensity exercise preserves muscle mass in the legs by attenuating NFkB-mediated protein-breakdown.

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### SPORT TRAINING AND OXIDATIVE METABOLISM IN LHCN-M2 HUMAN MYOBLASTS DURING MYOGENIC DIFFERENTIATION

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#### INTRODUCTION:

The human myoblast LHCN-M2, represent the first human-specific system of immortalized cells able to differentiate into mature myotubes. We demonstrate that different-types of sport training promote LHCN-M2 myoblast differentiation, inducing early and late myogenic markers expression in these cells (1,2). The aim was to investigate the effects of different-type of training on glycolytic and oxidative metabolism in the LHCN-M2 cells, during differentiation process.

#### METHODS:

Healthy young (19-28 y) males, long-term (at least 3y), differently trained ( $\geq 180$  min/week): swimmers (SW, n.6), bodybuilders (BB, n.6), soccer (SO, n.6) and volleyball players (VB, n.6), were recruited. Human sera pool (HC, Randox Laboratories Ltd., Crumlin, UK) was used as untrained control. Blood samples were collected 8h after the last training bout. LHCN-M2, were cultured in growth (GM, 15%FBS) or in differentiation medium, DM, supplemented with 0.5% serum from differently trained subjects or HC, respectively, for 4d. Myogenic differentiation was assessed by Fusion Index and CK activity, Myogenin (early marker) and MyHC- $\beta$  (late marker) mRNAs expression levels (2). The extracellular acidification rate (ECAR) and the oxygen consumption rate (OCR), markers of glycolysis and oxidative mitochondrial respiration, respectively, were measured using Seahorse XFe96 analyzer (Seahorse Bioscience, North Billerica, MA). For OCR: basal respiration, ATP-linked respiration, maximal respiration and for ECAR: basal glycolysis and glycolytic capacity were measured; data comparison between groups was performed using the ANOVA test, statistically significant  $p < 0.05$  after Bonferroni correction.

#### RESULTS:

ECAR and OCR resulted higher in proliferating (GM) compared to differentiated myoblasts ( $p < 0.001$ ). The ATP-linked respiration, associated to a decrease in the mitochondrial proton-leak, was higher in cells treated with "mixed" sports (VB + SO) compared to anaerobic (BB) ( $p < 0.05$ ) or HC sera ( $p < 0.001$ ), respectively, and in aerobic (SW) compared to HC ( $p < 0.01$ ) treated cells. Basal glycolysis rate was reduced in cells treated with sport-trained compared to HC sera ( $p < 0.05$ ); further, the glycolytic capacity result higher in cells treated with aerobic (SW) compared to anaerobic (BB) trained sera ( $p < 0.05$ ), respectively

#### CONCLUSION:

Our results suggest that sport training differently affects myoblast metabolism during differentiation. Interestingly mixed-sport, reducing proton-leak, seems protect cells against oxidative stress. A larger number of observation is in progress in order to confirm these results. This system represent an useful homologous paradigm to study the molecular and metabolic changes induced by different-type of training in myoblasts and to identificate the treshold of training-volume required to activate the differentiation process and to study the effects on the metabolism.

### UNRAVELING THE MOLECULAR CROSS-TALK LINKING LIFELONG FOOTBALL TRAINING AND HEALTH SPAN

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#### INTRODUCTION:

Football training is associated with higher VO<sub>2</sub>max and improved cardio-respiratory fitness. Increasing evidence shows the beneficial effects of football training on cardiovascular, metabolic and musculoskeletal health variables (1). Recently we showed at transcriptomic level that lifelong football training positively influences exercise-induced autophagy processes and protein quality control in skeletal muscle of elder subjects, thus promoting a longer healthy span (2). Here we analyzed the protein/metabolite expression profiles in muscle biopsies from Veteran football Players (VPG) compared to healthy age-matched untrained subjects (control group, CG).

#### METHODS:

Muscle biopsies of V. lateralis from 12 male volunteers (65–75 years), 6 belonging to VPG and 6 to CG, were analyzed by (phospho)proteomic/metabolomic strategies. Bioinformatic open source tools, such as DAVID (<https://david.ncifcrf.gov>) and STRING (<https://string-db.org>), allowed to classify the identified differentially expressed proteins according to gene ontology (GO) terms and to unravel molecular networks affected by the lifelong football training.

#### RESULTS:

Proteomic data showed that CPT1B, ACADSB, and ACAA2 enzymes, involved in the fatty acid degradation process, were overexpressed in muscle tissues from VPG compared to CG; accordingly, metabolomic data showed a reduced amount of long-chain saturated/hydroxylated/short/medium-chain branched acylcarnitines ( $p < 0.05$ ) in VSP vs CG muscle tissues, suggesting a more efficient aerobic oxidation in football players. This was also confirmed by phosphoproteomic analysis, through PLIN5 whose phosphorylation activates lipolysis.

Moreover specific subunits (PSMB1, PSMB4, PSMC4 and PSMC5) of 26S proteasome complex, regulating ornithine decarboxylase pathway, were underexpressed in VPG muscles in respect with CG; in this case, metabolomic data indicated that ornithine concentration was higher in VPG compared to CG ( $p < 0.05$ ), whereas the opposite behavior was observed for citrulline concentration ( $p < 0.05$ ).

#### CONCLUSION:

The integration of transcriptomic, proteomic and metabolomic data allowed to draw in muscles a molecular model unraveling the cross-talk between football training and a longer healthy span.

#### Acknowledgement

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## ROLE OF VON WILLEBRAND FACTOR AND ISCHEMIA MODIFIED ALBUMIN ON CARDIAC TROPONIN ELEVATION AFTER PROLONGED CYCLING

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### INTRODUCTION:

High-sensitivity c-reactive protein (hs-CRP), von Willebrand factor (vWF), and ischemia modified albumin (IMA) levels were the predictor for acute coronary syndrome.(1,2) Hs-CRP, vWF and IMA levels were also elevated after exercise.(3,4) cardiac troponin-I (cTnI) level is the gold standard for the diagnosis of myocardial infarction.(5) Previous study was also concluded that cTnI levels elevated after prolonged cycling.(6) However, little is known regarding the relationship between baseline hs-CRP, vWF, and IMA levels with post-exercise cTnI elevation. Current study is the advanced effort to explore the role of baseline hs-CRP, vWF and IMA levels on post-exercise cTnI elevation.

### METHODS:

Our previous report published elsewhere conducted pre- and post-exercise measurements of North Coast (NC) and Tour de Borobudur (TdB) 2017.(6) We determined baseline measurement i.e., blood count, hs-CRP, vWF, and IMA levels while cTnI levels were assessed pre- and post-exercise. Exercise intensity was also determined by heart rate captured during the exercise. cTnI elevated was determined when positive changes occurred. Eighty-eight male participants of both tours were involved in the study as reported(6); however, due to lack of blood specimens; finally, 80 participants were analyzed.

### RESULTS:

Male participants of NC and TdB completed the tour and met the data requirement of the study (N=80, age=46.04±11.36, exercise intensity:79.6±8.8%). Blood count, i.e. thrombocyte, lymphocyte, monocyte, hs-CRP, IMA, cTnI, were comparable between the tour group. While age, exercise intensity, and vWF levels were significantly different between the group. Based on the independent t-test analysis between the elevated and no-elevated cTnI group, we involved the exercise intensity (82.8±6.48% and 74.8±9.64%, respectively; p=0.001), vWF (4.1±1.92 ng/mL and 3.4±1.47ng/mL, respectively; p=0.08) and level of IMA (2.6±0.77 ng/mL and 2.1±0.76 ng/mL, respectively; p=0.007) in the binary regression analysis. Binary regression analysis concluded that exercise intensity and baseline IMA level were associated with cTnI elevation, while baseline vWF was not associated.

### CONCLUSION:

The current finding concluded that exercise intensity and baseline IMA level were related to the cTnI elevation, suggesting there was a role of IMA on the troponin elevation after exercise. vWF tends to be associated with cTnI elevation although, statistically not significant.

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## ATROPHY RESISTANT VS. ATROPHY SUSCEPTIBLE SKELETAL MUSCLES: A NOVEL EXPERIMENTAL PARADIGM TO STUDY THE MECHANISMS OF HUMAN DISUSE ATROPHY AND “ANABOLIC RESISTANCE” TO NUTRITION

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### INTRODUCTION:

Strategies (e.g. nutrition) to counter muscle wasting during disuse atrophy and catabolic diseases is a major goal of nutrition/muscle biology science efforts. However, the mechanisms of disuse atrophy and interactions between nutrient supply and preservation of muscle mass are equivocal e.g. some work shows efficacy of enhanced protein intake 1, while other work advocated limited potential 2. Here we took a novel approach to investigate the mechanisms of disuse atrophy in humans. We developed a new experimental medicine paradigm of investigating both atrophy resistant and atrophy susceptible muscles i.e. the disuse atrophy resistant tibialis anterior (TA) and susceptible medial gastrocnemius (MG) 3.

### METHODS:

Healthy young men (22±1y, BMI 23±1kg.m<sup>2</sup>) underwent 15-days unilateral leg immobilisation (ULI) using both knee and foot braces to immobilise the upper and lower leg. MRI and DXA scans were taken before, mid (~7d) and post (~15d) ULI. D2O was orally administered to monitor cumulative muscle protein synthesis (MPS) over the ULI period by mass spectrometry 4. After ULI, fasted TA and MG muscle biopsies were taken from both legs, before administration of IV amino acids (AA) and glucose for 2.5h to simulate feeding, with repeated TA/MG muscle biopsies.

### RESULTS:

After 7d ULI, leg lean mass (DXA) decreased by -3.2±0.7%, and -5.1±1.2% (p<0.05) by 15d. TA by DXA or MRI was unchanged after 15d ULI, while MG volume (MRI) decreased by -3.7±1.4% (p=0.06) after 7d, and thereafter stabilised by 15d (-3.0±1.6%, p<0.05). Non-ULI legs were unchanged. Cumulative MPS over 15d was reduced with ULI in TA and MG muscle vs. non-ULI muscles (TA control 1.22±0.07% vs. TA ULI 0.88±0.08% p<0.01, MG control 1.29±0.08% vs. MG ULI 0.82±0.12% p<0.01). MPS rates decreased to a greater extent in MG compared to TA (TA -22±4% vs. MG -38±7% p<0.05). In assessing nutritional influences (i.e. IV AA) on myocellular anabolic signalling in TA and MG muscles after 15d ULI, we saw a similar degree of acute AA-sensing pathway stimulation independent of ULI or atrophy susceptibility (e.g. mTOR fasted vs. fed, TA control +2.9±1.4, TA ULI +5.4±1.7, MG control +4.2±0.8, MG ULI +2.6±1.0; all fold-change; all p<0.0001).

### CONCLUSION:

Investigating atrophy susceptible vs. resistant muscles is a novel paradigm to study the mechanistic basis of disuse atrophy; using this model, we reveal that decreases in cumulative MPS underlie distinct muscle wasting rates. Since acute activation of AA-signalling in response to nutrient-intake was identical across muscles, we posit; first, anabolic resistance (i.e. attenuated MPS) to feeding occurs distal to mTOR signalling; second, depressions in post-absorptive MPS (~18h of a day) are likely to be the dominant mechanism in disuse atrophy.

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**ACUTE REMODELING OF THE INTRAMUSCULAR CONNECTIVE TISSUE NETWORK: WHICH STRENGTH-TRAINING EXERCISE INDUCES THE GREATEST RESPONSE IN THE ELDERLY?**

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**INTRODUCTION:**

The network of intramuscular connective tissues (IMCT) constitutes the collagenous backbone of the extracellular matrix of skeletal muscles. It provides mechanical support to muscle fibers, acts as medium for force transmission and fulfills important physiological roles in muscle development, growth and repair. While aging may lead to muscle fibrosis (Stearns-Reider et al, 2017), resistance exercise may counter this effect by stimulating both collagen production and degradation (Garg & Boppart, 2016). However, the efficacy of different forms of exercise is understudied. This study aimed to investigate the acute effects of 4 different exercise stimuli on genes associated with IMCT remodeling in senior subjects.

**METHODS:**

27 healthy men (66.9 ± 3.9 years) were recruited for the study. Following a familiarization trial, during which the knee extension 1-RM was determined, subjects were stratified to 2 out of 4 possible exercise groups: Group A performed conventional (concentric-eccentric, CE) leg extension exercise, group B conventional leg extension exercise assisted by foam rolling (CEFR), group C eccentric-only leg extension exercise (EX) and group D plyometric training using a commercially available jump training device (PLY). All exercises were performed unilaterally, with the non-trained limb serving as control condition. A washout period of two weeks was considered between the two exercise modalities assigned to each subject and the trained leg was switched between exercises. Six hours after cessation of exercise, biopsies were taken from the vastus lateralis muscle of both legs to evaluate the training stimuli based on the expression of 9 ECM-associated genes determined in a pilot study (MMP2, MMP9 and TIMP1 presented) (Wessner et al., 2018). Gene expressions were quantified by RT-PCR, expressed as -fold changes between trained and untrained limb and statistically compared by a mixed-factorial ANOVA ("exercise" as between- and "subject" as random-effects factor) and associated post-hoc pairwise comparisons.

**RESULTS:**

Only minor changes in MMP2 activity were seen after exercise, with no significant differences between exercise modalities (-fold changes 0.88-1.00, all  $p > 0.05$ ). MMP9, by contrast, was strongly upregulated by CEFR (3.80-fold change) and PLY (2.47-fold change), with differences between CEFR and CE as well as CEFR and EX (both  $p = 0.07$ ) tending towards significance. TIMP1 was notably upregulated following CEFR only (1.50-fold change). Here, the gene expression was significantly greater than after CE ( $p = 0.04$ ) and EX ( $p = 0.02$ ).

**CONCLUSION:**

The results of this acute study suggest that foam rolling and, to a lesser extent, plyometric exercise may stimulate the biosynthesis of MMP9, which is responsible for the breakdown of collagen IV, present in the basement membrane, thus promoting the remodeling of the IMCT network.

**EFFECTS OF AEROBIC EXERCISE OR CALORIC RESTRICTION ON ENERGY METABOLISM BY ACTIVATING FIBROBLAST GROWTH FACTOR 21 IN RATS**

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**INTRODUCTION:**

Both aerobic exercise and caloric restriction (CR) are known to induce metabolic remodeling in several organs and tissues, including white adipose tissue (WAT). Fibroblast growth factor 21 (FGF21) is a member of the FGF superfamily, which has important effects on lipid metabolism and energy balance. Previous studies also reported that FGF21 is a key regulator in the "browning" process of WAT, and regulates energy metabolism subsequently. This study aimed to investigate and compare the impacts of aerobic exercise or CR on energy metabolism through the "browning" of WAT which is mediated by FGF21.

**METHODS:**

Thirty male Sprague-Dawley rats were randomly divided into a control group (CON, n=10), an aerobic exercise training group (AE, n=10) and a caloric restriction group (CR, n=10). The rats' VO<sub>2</sub>max were determined in AE group and then they completed an aerobic exercise training program by running on a treadmill at an intensity of 60-70% VO<sub>2</sub>max, 5 days/wk, 60 min/day. The rats in CON group were fed ad libitum, but CR group was dietary restriction with 70% of CON energy intake everyday. After 8 weeks, the resting energy expenditure (REE) level was measured by using a comprehensive lab animal monitoring system. The inguinal WAT was collected and weighed, and the gene and protein expression levels of FGF21, β-Klotho, and UCP1 in WAT were detected. In addition, the blood lipid levels were measured from blood serum.

**RESULTS:**

After 8 weeks, the rats' body weight in AE and CR group were lower than that of CON group ( $p < .05$ ;  $p < .01$ ), and CR group was also lower than AE group ( $p < .01$ ). Compared with CON group, the WAT weight was lower in CR group ( $p < .05$ ). Both AE and CR group were lower in total cholesterol level than CON group ( $p < .01$ ). The REE level was 2.54±0.35 kcal/hr in CR group, which was lower than AE (3.21±0.76 kcal/hr) and CON (3.22±0.25 kcal/hr) groups ( $p < .05$ ). The mRNA level of FGF21 and β-Klotho were higher in AE group than both CR and CON groups ( $p < .05$ ;  $p < .01$ ); compared with CON group, the protein level of FGF21 and β-Klotho were greater in AE and CR groups ( $p < .05$ ;  $p < .01$ ). In addition, no significant difference was observed in UCP1 protein level among groups.

**CONCLUSION:**

Both aerobic exercise training and CR intervention increased the expression of FGF21 and its co-receptor of β-Klotho in WAT, which resulted in a reduction of body weight. However, the body weight management was not associated with REE level, and FGF21 may have different mechanisms in regulating energy metabolism under the intervention of aerobic exercise or CR.

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**OP-PN09 Sleep****A-LACTALBUMIN IMPROVES SLEEP AND RECOVERY FOLLOWING SIMULATED EVENING COMPETITION IN FEMALE ATHLETES**

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UNIVERSITY OF CANBERRA

**INTRODUCTION:**

Consumption of the whey protein a-lactalbumin (A-LAC) may increase total sleep time (TST) and sleep efficiency in healthy general population males [1]. However, there is currently no evidence describing the effects of A-LAC supplementation on sleep in athletic populations. The purpose of this investigation was to determine the efficacy of A-LAC supplementation to improve sleep, as well as performance recovery following a simulated evening competition in female athletes.

**METHODS:**

During this randomised double-blind three-arm crossover study, sixteen well-trained female athletes (mean  $\pm$  SD; age  $27 \pm 7$  years; mass  $62 \pm 10$  kg; stature  $167 \pm 8$  cm) visited the laboratory for three familiarisations, three baseline assessments (with polysomnography [PSG] adaptation), and three experimental trials. During the experimental trials, participants completed an evening competition simulation and then consumed either an A-LAC whey protein, a whey protein isolate placebo (PLA) or a water control (CON) beverage. Sleep was monitored via PSG and participants completed a series of physical (Yo-Yo Intermittent Recovery Test Level 1 [YYIRL1], countermovement jump [CMJ], 20 m sprint), cognitive (Stroop task) and perceptual (NASA Task Load Index [NASA-TLX]) assessments at baseline, and 14 and 24 h post simulated competition.

**RESULTS:**

Participants TST was  $19 \pm 7$  min ( $p = 0.008$ ) longer pre compared to post competition. Non rapid eye movement stage 2 (NREM2) sleep increased post competition in A-LAC (pre  $199 \pm 44$  min; post  $212 \pm 37$  min) but decreased in CON (pre  $228 \pm 43$  min; post  $195 \pm 40$  min) and PLA (pre  $224 \pm 25$  min; post  $211 \pm 35$  min;  $p = 0.012$ ). NREM3 increased post competition in CON (pre  $116 \pm 15$  min; post  $139 \pm 27$  min), A-LAC (pre  $129 \pm 27$  min; post  $136 \pm 25$  min) and PLA (pre  $122 \pm 17$  min; post  $128 \pm 26$  min;  $p = 0.004$ ). YYIRL1 distance was different over time in A-LAC (baseline  $664 \pm 332$  m; 14 h post  $667 \pm 326$  m; 24 h post  $781 \pm 427$  m) compared to CON (baseline  $741 \pm 366$  m; 14 h post  $648 \pm 351$  m; 24 h post  $720 \pm 407$  m) and PLA (baseline  $763 \pm 394$  m; 14 h post  $636 \pm 366$  m; 24 h post  $720 \pm 396$  m;  $p < 0.001$ ). Stroop task NASA-TLX mental demand reduced over time in A-LAC (baseline  $11.2 \pm 5.2$ ; post 24 h  $9.6 \pm 5.2$ ) compared to increases in CON (baseline  $12.3 \pm 4.6$ ; 24 h post  $14.0 \pm 3.8$ ) and PLA (baseline  $10.7 \pm 5.4$ ; 24 h post  $11.4 \pm 5.5$ ;  $p = 0.002$ ).

**CONCLUSION:**

Following an evening competition simulation, modest improvements in some sleep characteristics were observed with A-LAC consumption relative to PLA and CON. A-LAC also led to the retention of aerobic capacity, and reduced mental demand compared to PLA and CON. Overall, the present findings indicate that A-LAC supplementation may elicit modest improvements in sleep following evening competition, potentially improving aspects of performance recovery.

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**ELITE AGE GROUP TRIATHLETES COMPETING AT THE IRONMAN™ WORLD CHAMPIONSHIP EXHIBIT SIMILAR SLEEP DURATION AND QUALITY DURING A TRAINING AND RACING WEEK**

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**INTRODUCTION:**

Previously, we have demonstrated that >50% of triathletes, leading up to the 2015 IRONMAN™ World Championship, subjectively reported (via the Pittsburgh Sleep Quality Index) poor sleep quality during the month prior to the race. However, limited objective data exists in this cohort on sleep characteristics on both a training and race week. The purpose of this investigation was to objectively measure sleep quantity and quality, via wrist worn actigraphy, of elite age group triathletes during a training week and the week leading up to a world championship race, to determine differences and if sleep interventions are warranted.

**METHODS:**

Seventeen triathletes (9 female, 8 male) competing in the 2017 IRONMAN™ World Championship (Kailua-Kona, Hawaii, USA) participated in this investigation. The triathletes (age:  $37.9 \pm 6.8$  y, range: 27-52 y) slept with a wrist-worn actigraphy biosensor (Philips Actiwatch Spectrum Plus) during a training week (TW, ~4 wk prior to race day) to record sleep quantity and quality. A subset ( $n=12$ ) also wore the biosensor in the 2-5 days leading up to the competition (Race week (RW)). Sleep duration and quality (sleep onset latency (SOL), sleep efficiency, and wake after sleep onset (WASO) were determined via software (Philips Actiware 6). Poor sleep quality was determined by a SOL < 8 min, a sleep efficiency < 85 %, and a WASO > 30 min. A paired samples t-test was used to compare TW vs. RW ( $p < 0.05$ ).

**RESULTS:**

During TW, triathletes were found to be in bed  $8.1 \pm 0.6$  h/d and to sleep  $6.9 \pm 0.5$  h/d. They had a  $13.5 \pm 10.2$  min/d SOL,  $85.3 \pm 4.7$  % sleep efficiency, and  $49.2 \pm 17.7$  min/d WASO. During RW, hours spent in bed and hours asleep were  $7.7 \pm 0.7$  h/d and  $6.4 \pm 0.9$  h/d, respectively. In the same week the triathletes had a SOL of  $13.5 \pm 24.4$  min/d,  $82.9 \pm 6.9$  % sleep efficiency, and  $46.4 \pm 16.3$  min/d WASO. There were no significant differences in sleep quantity or quality between TW and RW ( $p > 0.05$ ).

**CONCLUSION:**

In this investigation, average sleep quantity and quality measured via actigraphy were not significantly different between TW and RW. However, on average, most measurements of sleep quality, except TW WASO, were sub-optimal and a large proportion of the individual athletes exhibited poor sleep quality. On an individual level ~47 % of the athletes during TW had poor SOL and sleep efficiency, and ~70 % had a WASO > 30 min. During RW, 58 % of the athletes had a lower SOL and sleep efficiency, and 83 % had poor WASO. Future research could include investigating unique factors contributing to poor sleep quality during training and race weeks, and also testing interventions in both conditions to mitigate those issues.

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**EXPLORATION OF POTENTIAL FACTORS ACCOUNTING FOR SLEEP VARIABILITY AMONG ATHLETES**

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**INTRODUCTION:**

Sleep is well recognized as one of the most important component of the recovery process among athletes (Venter, 2014). Despite of that, recent studies reported reduced sleep quality and quantity and higher sleep variability among elite athletes compared with age- and sex-matched non-sporting controls (Leeder et al., 2012). Many factors were proposed as potentially accounting for this sleep variability including travel, sleep hygiene, stress and training and competition schedules and load (Gupta et al., 2016). The aim of this study was to explore the potential effect of external and internal factors related to elite sport on sleep quality and quantity among athletes.

**METHODS:**

180 elite athlete participated in this study. They represented 12 different Olympic sports (volleyball n = 11, tennis n = 8, soccer n = 50, swimming n = 11, archery n = 15, badminton n = 16, road cycling n = 12, fencing n = 13, golf n = 8, handball n = 19, field hockey = 10, rifle shooting n = 7). General subjective measures were collected prior the study to characterize the sleep profile of each athlete. After that, athletes' sleep (using actigraphy) and perceived training load were monitored during an in-season training week. Hierarchical clustering on principal component analysis (using wake after sleep onset, sleep fragmentation and sleep onset latency) was used to reduce data into 3 clusters of sleep quality. Comparison of each variable (practised sport, weekly training load, intraindividual variability [IIV] of sleep, chronotype, etc) between the clusters were then conducted to assess its effect on sleep quality.

**RESULTS:**

The main results showed a reduced sleep quality and quantity for elite athletes compared with the national sleep foundation recommendations. Moreover, a significantly higher proportion of cyclists and swimmers was observed in the cluster presenting the worst sleep quality. Our data reported a higher IIV in assumed sleep and sleep schedules median among the cluster characterized by a high sleep onset latency (SOL). A significant correlations were observed between SOL and IIV in assumed sleep ( $r=0.29$ ;  $p<0.001$ ) and IIV in sleep schedules ( $r=0.30$ ;  $p<0.001$ ).

**CONCLUSION:**

Athletes did not reach the recommendations of sleep quality and quantity which may compromise their recovery process and performance. The type of sport may have an influence on sleep quality as cyclists and swimmers presented a worst sleep quality than the other sports. Finally, increased IIV variability in sleep schedules and quantity was shown to increase SOL.

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**PHYSICAL ACTIVITY, SEDENTARY TIME AND SLEEP IN CHILDREN AND ADOLESCENTS WITH CYSTIC FIBROSIS: A BI-DIRECTIONAL RELATIONSHIP?**

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**INTRODUCTION:**

As acknowledged in recent movement guidelines for children and youth, physical activity, sedentary time and sleep are inherently inter-related. However, the presence of a bi-directional relationship between physical activity and sleep in children remains equivocal. No evidence regarding this relationship is available in those with Cystic Fibrosis (CF), despite the central role of both sleep and physical activity in treatment strategies.

**METHODS:**

Parameters of physical activity, sedentary time and sleep were derived from hip-worn accelerometers over seven consecutive days in 58 youth ( $11.9\pm 2.7$  years; 29 CF). Generalised linear latent and mixed models with a random intercept and slope at the child-level were adjusted for age, sex, wear-time, type of day, condition and mean physical activity/sleep, as appropriate.

**RESULTS:**

Every additional 10 mins spent sedentary was associated with 5.2 mins less sleep and 11.4 mins less wake after sleep onset that night, irrespective of condition. Physical activity was not associated with total sleep time, but every additional 10 mins of light physical activity was associated with 2.2 and 3.0 mins less wake after sleep onset, overall and in healthy participants, respectively. Ten mins more sleep was associated with 2.3, 3.1 and 1.7 mins less sedentary time overall and for CF and healthy controls, respectively. Overall, and in those with CF, more sleep led to less light physical activity the following day. In the healthy children, wake after sleep onset was also associated with more light physical activity (1.4 mins) and moderate-to-vigorous physical activity (5.2 mins) the following day.

**CONCLUSION:**

These findings have important implications regarding the reciprocal effects of promoting physical activity and/or sleep quantity or quality in future interventions for healthy children. However, in those with CF, fewer associations were observed between variations in sleep and physical activity, possibly due to strictly controlled treatment strategies, which limit flexibility and, potentially, opportunities for physical activity. Given that reciprocal benefits may not be manifest in those with CF, future interventions need to separately target these parameters.

**OP-SH01 PA Promotion****ASSOCIATIONS BETWEEN PHYSICAL FITNESS AND COGNITIVE IMPAIRMENT IN OLDER PEOPLE: THE EFICCOM PROJECT**

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**INTRODUCTION:** In the last decade it has shown that physical fitness, particularly cardiorespiratory fitness and muscular strength, are powerful marker of health. Most of the studies published are highlighted the relevance of having a good fitness for health in youth and adulthood. However, the information about the relationship between a set of components of fitness and cognition in older people is lacking. Therefore, the aim of this study was to examine the associations of a set of physical fitness components (i.e., cardiorespiratory fitness, and muscular strength) with cognitive impairment in older people. **METHODS:** This study included cross-sectional baseline data from the EFICCOM project (Clinical Trial registration: NCT03923712). A total of 51 older people at risk of mild cognitive impairment (69.3±3.1 years, 19 women) participated in our study. Cardiorespiratory fitness was assessed by the 6 min walking test (metres reached). Muscular strength was evaluated by handgrip (kg) and chair stand tests (seconds based on the SPPB battery). Cognitive impairment was evaluated by Clock Drawing Test (CDT). Linear regressions analyses were applied after adjusting for basic confounders (i.e. age, sex, and educational years). **RESULTS:** Cardiorespiratory fitness ( $\beta=0.229$ ,  $p=0.129$ ) and muscular strength ( $\beta=0.223$ ,  $p=0.254$  for handgrip, and  $\beta=-0.006$ ,  $p=0.970$  for chair stand) were not significant associated with cognitive impairment. **CONCLUSION:** Overall, cardiorespiratory fitness and muscular strength were not related to cognitive impairment in older adults. Yet, our findings show a positive trends between fitness and cognition. Further studies with larger sample sizes should corroborate or contrast our findings.

**ASSESSING THE ROLE OF THE TRAINER IN ADAPTED PHYSICAL ACTIVITY FOR OSTEOPOROTIC PEOPLE IN ORDER TO IMPROVE THEIR QUALITY OF LIFE: ANALYSIS FROM THE OSTEO-APA STUDY**

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**INTRODUCTION:**

The management of osteoporosis is multi-modal and includes exercise, often recommended as a beneficial non-pharmacological treatment to slow the rate of bone loss<sup>1</sup>. Exercise programs may be conducted by trainers able to deal with people at high risk of fracture, because exercise alone, even if in the right dosage seems to be not enough to improve the quality of life. The aim of this analysis was to assess, using mixed-methods the role of the trainer in conducting an Adapted Physical Activity (APA) protocol designed for people with osteoporosis and vertebral fractures in order to improve their quality of life.

**METHODS:**

The intervention group (APA) performed 1 hour twice a week for 6 months exercise protocol, while the Control Group (CG) received the generic indication on the importance of physical activity. Quality of life (QoL) was assessed at the baseline and at the end of the study with ECOS-16 questionnaire and semistructured interviews to understand women perceptions regarding the role of the trainer. Quantitative and qualitative data were analyzed using SPSS 5 and NVivo 12, respectively.

**RESULTS:**

Forty post-menopausal women (mean age: 67.6±4.6) divided in two group APA group = 22 and CG = 18, completed the study.

At follow-up, APA group improved significantly the quality of life (APA: -0.5±0.5 vs CG: 0.0±0.3  $p=0.02$ ). The APA intervention had a significant effect on all the components of QoL, as measured by the disease-specific ECOS-16 questionnaire: Physical Component Summary (PCS) (APA: -0.4±0.5 vs CG: 0.0±0.4  $p=0.06$ ) and Mental Component Summary (MCS) (APA: -0.5±0.6 vs CG: 0.1±0.5  $p=0.02$ ). The interviews confirmed this result, emphasizing the key role of the trainer in improving their QoL. No injuries were observed.

**CONCLUSION:**

The study showed that this APA program is feasible, safe and significantly able to improve the quality of life in postmenopausal women. Compared to what recent literature reports, for which it is not clear why exercise is not able to improve the QoL in people with osteoporosis and vertebral fractures, we can suggest that trainers specifically educated, could be a means of achieving the goal. Their function is so important especially in this conditions, as they do not only occupy the role of exercise experts but also an educational, relational and support role.

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**KEYWORDS**

Adapted physical activity, osteoporosis, quality of life, trainer's role, patient centered model

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**PHYSICAL ACTIVITY-BASED PROJECT ADVENTURE AT PRIMARY SCHOOL TO PROMOTE SOCIAL SKILLS**

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**Introduction**

Studies show that participation in a physical activity-based program could be associated with improvement in social competence (McDonough et al., 2013; Ullrich-French & McDonough, 2013). By exercises promoting teamwork and minimizing competition a physical activity-based program can provide opportunities to develop pro-social skills through conflict resolution and cooperation (Fraser-Thomas, Côté & Deakin, 2005). The purpose of the study was to analyse, if the participation in a physical activity-based project adventure at primary school reduces the occurrence of conflicts.

**Method**



67 girls and 85 boys aged 6-11 (Mage=8.21, SD=1.34) participated in four physical activity-based project adventure in school holidays providing opportunities to improve social competences and emphasize relationship-building. The 5-days programs include daily topics to promote pro-social behaviour like responsibility, respect, and cooperation. We adopted a quasi-experimental design with two measurements (pre-test, post-test). The occurrence of conflicts and brawls at school (e. g. "Some have said hurtful things to me") was rated with a German scale of social conflicts (Buchwald, 2004) by the elementary students on a 3-point scale of 1 (often agree), 2 (sometimes true) and 3 (disagree).

**Results**

As expected, the Wilcoxon Test showed statistically significant differences between the beginning and the end of the intervention ( $z = -4.923$ ;  $p = .000$ ). The self-reported occurrence of social conflicts and brawl decreased (Mpre= 2.34, SD = .34; Mpost= 2.45, SD = .4).

**Discussion**

Our findings underline the importance of considering the social context when implementing physical activity-based programs. Elementary school children may gain benefits from the participation in a physical activity-based project adventure. There may be long-term effects of participation in the program that are not assessed by the current study due to the short length of the intervention program. Furthermore, future work should continue to explore the teacher-student relationship to improve social skills.

**THE EFFECTS OF A ROCK DRUMMING INTERVENTION ON CHILDREN WITH ADDITIONAL EDUCATIONAL NEEDS**

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**INTRODUCTION:**

Rock drumming is a powerful model as a physical activity intervention since it combines physical activity, music and four limb coordination into an engaging and enjoyable activity. We have demonstrated how drumming can; be developed into a form of vigorous activity [1], result in significant changes in the brain [2] and be incorporated into the school day [3]. The aim of this study was to evaluate the effectiveness of a group drumming intervention in children with a wide range of additional educational needs including autistic spectrum disorder.

**METHODS:**

Fourteen children (aged 12-14 y) from a large special education school, took part in the study. The children learned drumming at electronic drum kits arranged in a circle around the tutor's kit. Lessons were 30-40 minutes, twice per week for 10 weeks and included instruction as well as playing to popular music in the classroom. Pre and post the intervention, the children were assessed for motor skill (ABC2) and teachers completed the Strengths and Difficulties Questionnaire (SDQ). In addition, an electronic record of all lessons was made by capturing the MIDI data from the drum kits. Finally focus groups were held with parents and teachers post intervention to investigate benefits beyond those seen at the drumming lessons.

**RESULTS:**

There was a significant improvement ( $P=0.039$ ) in the internalising score for the SDQ (combination of emotional and peer problems). Whilst motor skill improvement was clear in the MIDI data capture, ABC2 scores were not significantly different (in this highly variable sample). However, focus groups indicated that parents and teachers had seen profound changes in behaviour and motor skill, for example one child could successfully clean his own teeth properly for the first time by the end of the short intervention.

**CONCLUSION:**

Rock drumming using electronic kits is a valid and powerful form of physical activity intervention, yielding both physical and behavioural improvements in this population. Children involved in this study were also able to perform for their parents and carers for the first time in their school life. Furthermore, the school has adopted drumming onto their curriculum and continues to see benefits in the children participating.

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**EFFECT OF A POSITIVE YOUTH DEVELOPMENT PROGRAM ON LEADERSHIP SKILLS IN FEMALE YOUTH VOLLEYBALL PLAYERS**

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**Introduction:** Leadership in team sports has been addressed in the scientific literature through a theoretical model that entails the existence of two main orientations in leaders: social orientation, focused on personal relationships and the dynamics produced within the team; and task orientation, which involves behaviors aiming to achieve sport results. Leadership skills are one of the main skills addressed in Positive Youth Development (PYD) programs, which are proliferating nowadays. Two of the main PYD programs are the Teaching Personal and Social Responsibility Model (TPSR) and the Sport Education Model (SE). The aim of this study is to analyze the effect of the application of a hybridized PYD program combining TPSR and SE on leadership in female youth volleyball players.

**Method:** A mixed-method design was employed. 30 girls who were part of two different volleyball teams took part in the study (15 in the experimental group, 15 in the control group). Quantitative data assessed components of leadership in both social orientation (empathy, influence on decision making, sport values, social support) and task orientation (competition and training orientation). Data was obtained using EELD-24 questionnaire and analyzed using SPSS 26.0 software. Qualitative data assessed participants' insight of leadership learning inside and outside sport. It was obtained using semi-structured interviews and analyzed using NVivo 12 software.

**Results:** Non-parametric tests were used, finding no significant differences between the leadership and task components (pretest and posttest). Qualitative data analysis showed positive results in almost every girl in the experimental group, both in leadership within sport and leadership out of a sportive context. There were three overarching themes in both inside and outside sport leadership: directing people, helping others and communication. A fourth theme was present within sport: motivating others.

**Discussion:** The results showed an improvement in sport values, social support, competition orientation and training orientation, however the differences were not significant. In addition, within the sportive context, the prevalent insight was related to an enhancement in leadership in the majority of cases. The ability of directing people was the main field of improvement, and most of the girls who felt a development in their directing skills also stated an enhancement in helping others and in their communication abilities. Those findings inside sport

were directly related to the findings outside sport: the majority of participants felt an improvement in directing others, helping others and in their communication abilities. Considering those findings, the application of a hybridized PYD program in female youth volleyball players involves an improvement in leadership skills and self-perception of players' capabilities of leading others. However, more studies are needed that use larger samples to strengthen these results.

### **INFLUENCE OF AGE, GENDER, DAY LENGTH AND TEMPERATURE ON PHYSICAL ACTIVITY LEVELS OF BOYS AND GIRLS IN ELEMENTARY SCHOOL. THE HEALTH ORIENTED PEDAGOGICAL PROJECT (HOPP).**

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#### **INTRODUCTION:**

The aims of the study were to 1) estimate longitudinal and secular changes in physical activity level (PA) in elementary school students between 2015 and 2019 and 2) look at the relationships between weather conditions and physical activity in 2015.

#### **METHODS:**

The study sample consisted of 2105 subjects in 2015 (50% females) aged 6 – 12 years from the Norwegian HOPP study. Moderate-to-vigorous physical activity (MVPA) and sedentary behaviour (SED) were objectively assessed using Actigraph wGT3X-BT based on six-day averages in January–June and September–October each year to 2019. Local meteorological data from 2015 were compiled by The Norwegian Meteorological Institute. The accelerometer-monitored physical activity of children grouped within nine schools participating was matched with regional weather conditions and assessed with the means of linear mixed models.

#### **RESULTS:**

Over the 5 years, MVPA declined by 2 min-day<sup>-1</sup> ( $p < 0.001$ ), and SED increased by 6 min-day<sup>-1</sup> ( $p < 0.001$ ) in the longitudinal analysis. MVPA was lower by 5 min ( $p < 0.001$ ) per additional year of age. SED increased by 21 min per year of pupil's age in the secular analysis. Males were 12.3 min-day<sup>-1</sup> more active (95% CI: 11.1–13.5) than females at all age groups ( $p < 0.001$ ). Increased day length was associated with decreased sedentary behaviour. Warmer temperature and dry weather were associated with increased moderate-to-vigorous physical activity after adjusting for age and sex. One-hour increase in daylight resulted in a decrease of sedentary time by, on average, 2 min (95% CI = (-2.6, -0.8)). For every 5 °C increase in temperature (range: -0.95 and 15.51 °C) and dry weather, average moderate-to-vigorous physical activity increased by 72 and 67 min (males and females, respectively) ( $p < 0.001$ ). Days with precipitation had, on average, 10 fewer minutes of moderate-to-vigorous physical activity compared with days without precipitation (95% CI = (-16.7, -3.3)). Higher temperatures and dry weather led to higher physical activity levels, seeing larger increases among boys than girls.

#### **CONCLUSION:**

Physical activity levels declined substantially starting at age 6 years. Day length and temperature have a clear influence on PA level. A school-based physical activity intervention program should be adjusted according to local weather.

### **SPORTY SUMMER AND LAZY WINTER? PA OF YOUTH FROM A SEASONAL PERSPECTIVE.**

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#### **Objectives:**

Many children in Europe are insufficiently active (1), which makes the promotion of children's physical activity (PA) a critical health promotion target. However, there are some uncontrollable factors such as amount of daylight, weather conditions, temperatures and precipitation levels that might influence PA behavior (2). Conditions for moderate to vigorous physical activity (MVPA) seem to be optimal when the environmental temperature ranges between 20°C and 25°C (3). This study aims to examine if the season is related to the objectively measured PA of youth of Luxembourg.

#### **Methods:**

150 youth (90 females and 60 males) aged from 10–17 ( $M = 12.37$ ,  $SD = 2.14$ ) years participated in this longitudinal study, which took place at two measurement periods, the first between October and December (winter) and the second between May and July (summer). PA behavior was objectively assessed by wearing an accelerometer (ActiGraph GT3X-BT) for seven consecutive days. Daily time spent in MVPA was calculated as an indicator of the youth's PA behavior.

#### **Results:**

A repeated measures ANOVA revealed a significant seasonal effect for MVPA per day ( $F(1, 1136.66) = 9.14$ ,  $p < .05$ , partial  $\eta^2 = .06$ ). More minutes of MVPA per day were accrued in summer ( $M = 53.24$ ,  $SD = 21.40$ ) than in winter ( $M = 49.04$ ,  $SD = 20.88$ ). Both in winter and in summer, MVPA per day differed significantly between females and males (winter:  $t(148) = 5.83$ ,  $p < .001$ ; summer:  $t(148) = 4.85$ ,  $p < .001$ ), whereby females (winter:  $M = 41.70$ ,  $SD = 15.89$ ; summer:  $M = 46.79$ ,  $SD = 17.26$ ) showed significantly fewer minutes in MVPA per day than males (winter:  $M = 60.05$ ,  $SD = 22.67$ ; summer:  $M = 62.91$ ,  $SD = 23.43$ ). However, there was no significant interaction between season and gender,  $F(1, 89.85) = .723$ ,  $p = .397$ .

#### **Discussion:**

According to the results of this study, youth are less physically active in winter than in summer. Therefore, schools, sports clubs and communities should offer special PA programs for this season, which are independent from climatic conditions and equally suitable for females and males. Measuring PA throughout the year enables to monitor the activity behavior more accurate and may help in developing such programs.

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## COMPARING SELF-REPORTED AND ACCELEROMETER-BASED PHYSICAL ACTIVITY OF YOUTH: DOES THE OVERESTIMATION REMAIN STABLE THROUGHOUT THE YEAR?

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**Objectives:** The few studies measuring physical activity (PA) via self-report questionnaire and accelerometer consistently show that people tend to overestimate their activity level. This applies to all age groups while the influence of personal and social variables remains unclear (1). Since the misperception of one's own PA can be a potential barrier of behavior change, it is important to understand the relationship between subjectively perceived and objective PA. Therefore, in a longitudinal extension of a previous study (2), this paper aims to examine how self-reported and objective PA are related to each other over the year.

**Methods:** 137 youth from Luxembourg (81 females and 56 males) aged from 10–17 (M = 12.37, SD = 2.16) years participated in the study. PA was measured twice (t1: 10-12/2018, t2: 5-7/2019) by an online questionnaire including the item "How many minutes per day are you physically active?" (self-reported PA) and by wearing the ActiGraph GT3X-BT accelerometer for one week (objective PA). Daily PA time scores and mean difference scores between self-reported and objective PA were computed and analyzed in terms of stability and relation.

**Results:** At t1, 11.7% of the participants reported a daily PA time that complies on a  $\pm 5$  minutes level with the objectively measured PA. 60.6% overestimated and 27.7% underestimated their PA. At t2, the values only changed slightly to 15.3 % compliance, 55.5 % overestimation and 29.2 % underestimation. A closer look at the participants who have overestimated their PA level at t1 reveals that a majority of 62.7% maintained this misperception at t2. However, 15.7 % of this group reported now a PA time that corresponds to their objective PA and, surprisingly, 21.7 % even underrated their PA at t2. Mean difference scores between self-reported and objective PA at t1 and t2 were correlated ( $r = .31, p < .001$ ) indicating a high stability of PA-related misperceptions among young people.

**Discussion:** The results of our study show that the misperception of one's own PA, especially in the sense of an overestimation, is a common and relatively time-stable phenomenon among youth. Besides the scientific perspective, this is a crucial aspect in the practice of PA and health promotion and rehabilitation.

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## PHYSICAL EXERCISE ADHERENCE IN PATIENTS WITH TYPE 2 DIABETES; A CULTURAL MATERIALISM INTERPRETATION OF THE TRANSTHEORETICAL MODEL OF BEHAVIOR CHANGE

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**INTRODUCTION:**

Although physical exercise is a biological necessity to maintain health in humans, we live in a culture where this necessity is not accomplished. Physical exercise is a key behavior to prevent and control health problems, including type 2 diabetes. However, low adherence to physical exercise –which is subject to cultural and social norms and barriers– needs to be addressed to change patients' behavior. The transtheoretical model of behavior change has been widely used to help people increase their daily dose of physical exercise. However, exercise protocols are part of patients' cultural context and therefore, behavior change should not be considered as an individual process but as a collective one. For a better comprehension of that issue, this qualitative study aims to reinterpret the transtheoretical model with a new perspective through the anthropologist method research known as cultural materialism.

**METHODS:**

A qualitative study with four focus groups and five semi-structured interviews with type 2 diabetes patients (n= 9 men, 11 women; 58 to 83 years old) were carried out between April 2019 and January 2020. Questions related to different steps of the transtheoretical model–about patients' predisposition to start or maintains a physical exercise program and the facilitators and barriers perceived– were asked. The answers were linked to a priori categories that belong to cultural materialism theory. This method suggests that all behavior rest on the relationship between the natural environment and the methods used to obtain resources needed to survive (i.e. infrastructure), and that determines the difference and similitudes of the different human cultures (i.e. superstructure). Then these categories were associated with the transtheoretical model steps.

**RESULTS:**

The results suggest that being physically active through physical exercise protocols become a basic social process when the transtheoretical model is interpreted through cultural materialism. Patients with diabetes have to overcome superstructure barriers through a basic social psychological process and infrastructural barriers through a basic social structural process. While the psychological process is necessary to change behavior and to start a physical exercise program, the social process is needed to maintain these changes. Thus, the transtheoretical model should be reinterpreted as two different processes.

**CONCLUSION:**

Behavior change involves two different basic social processes. Although one without the other loses all their meaning, they should be analyzed as different issues. Consequently, if the transtheoretical model is split into two different pieces, physical exercise adherence and behavior change studies should be focus on one of these two processes. Otherwise, their conclusions could be lost due to survivorship bias. Future studies related to change behavior and physical exercise adherence should be aware of this interpretation.

## OP-SH02 Psychology and Mental Health

### IMPACT OF PUBLIC AND SELF-STIGMA ON ATTITUDE TOWARD SEEKING MENTAL HEALTH SERVICE AMONG JAPANESE UNIVERSITY ATHLETES

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#### INTRODUCTION:

Athletes' mental health is a great concern for coaches, supporters, and researchers in the field of sports science. Stigma is one of the suppressive factors to attitude toward seeking mental health service in general population. Stigma is the perception of being flawed because of a personal or physical characteristic that is regarded as socially unacceptable (Blaine, 2000). Stigma composes of two types: public stigma and self-stigma (Corrigan, 2004). Public stigma is the perception held by a group or society that an individual is socially unacceptable. Self-stigma is the reduction of an individual's self-esteem or self-worth caused by individual self-labeling herself or himself as someone who is socially unacceptable. Stigma may reduce help seeking toward mental health service, but its actual conditions among Japanese university athletes has not been clarified. Therefore, we examined the impact of public and self-stigma on attitude toward seeking mental health service among Japanese university athletes.

#### METHOD:

We collected data from 703 Japanese university athletes (456 men and 247 women). We collected information on athletes' demographics, Social Stigma for Seeking Psychological Help (SSRPH) scale, Self-Stigma of Seeking Help (SSOSH) scale, and Attitudes Toward Seeking Professional Psychological Help Scale (ATSPPHS). Regression analysis was performed with SSOSH and SSRPH scores as independent variables and ATSPPHS score as a dependent variable, considering confounding factors.

#### RESULTS:

A regression analysis showed that public stigma and self-stigma had significant negative effects on attitude toward seeking mental health service ( $\beta = -.27, p < .001, \beta = -.36, p < .001$  respectively,  $R^2 = .30$ , adjusted  $R^2 = .29$ ).

#### DISCUSSION & CONCLUSION:

This indicates that athletes' public and self-stigma suppress attitude toward seeking mental health service. Self-stigma is a stronger predictor to attitude toward seeking mental health service, compared with public stigma. Thus, we concluded that public and self-stigma have an impact on attitude toward seeking mental health service of Japanese university athletes. Sports coaches and supporters of athletes should pay substantial attention to athletes' public and self-stigma to foster their help seeking to mental health service.

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### DUAL CAREER PATHWAY: THE EFFECT OF SPORT ENGAGEMENT ON SPORT AND SCHOOL BURNOUT, AND SCHOOL ENGAGEMENT IN LOWER SECONDARY SCHOOL STUDENT ATHLETES

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#### Introduction

Youth sports participation, in general, is associated with beneficial academic, physical and psychological developmental outcomes. However, little is known about student athletes' academic and athletic development during early Dual Career (DC) stage, a period of intensifying schooling demands in lower secondary school coinciding with the specializing years (ages 13–15) in sports. According to the social exchange theory, mutual and dynamic influences of individual investment in sports and key sources of social support influence individual development in multiple contexts. The aim of the study was to determine the effect of sport engagement on sport and school burnout, and school engagement.

#### Methods

The study group of the research consisted of 465 student athletes (boys 56 %) representing 19 Finnish lower secondary sports schools who filled in a questionnaire in the beginning of lower secondary school (grade 7). The research data were analyzed using structural equation modeling. Sport engagement comprised an affective dimension and a cognitive dimension, whereas school engagement comprised a behavioral dimension. Sport and school burnout was examined using the School-Burnout Inventory with parallel worded items.

#### Results

The results displayed that cognitive engagement in sports was associated with lower levels of sport burnout, and higher levels of school burnout. The results also showed that social support from teammates and coaches related to lower levels of perceived sport burnout and social support for sports from peers to higher levels of school burnout. Maternal and peer social support for sports was connected to higher school engagement, whereas paternal support for sports was neither related to school engagement nor sport or school burnout. Finally, girls perceived higher levels of maternal and peer support for sports, whereas higher level of competition was positively associated with maternal support for sports.

#### Discussion/Conclusion

Student athletes at the beginning of their educational and sports careers might have to choose how to distribute their limited resources. In line with the social-exchange theory, the results of this study support the notion that sport engagement is associated with both costs and rewards. Cognitive engagement (future aspirations, control and relevance) and social support from peers displayed the strongest relationships with sport burnout, but predisposed simultaneously student athletes to school burnout. Athletes may have more resources, such as social support or perceptions of competence, in one domain and fewer resources in the other domain, which may spill over to the other domain. Indeed, in this study maternal and peer support for sport strengthened school engagement. Appropriate strategies to enhance social relationships and individual resources in sport is key to support athletes with differing levels of commitment to school and sport.

### EFFECT OF MENTAL FATIGUE ON COGNITIVE FUNCTION AND PHYSIOLOGICAL RESPONSES TO EXERCISE IN REFEREES

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#### INTRODUCTION:

Mental fatigue is a psychological phenomenon that is caused by prolonged and/or demanding cognitive activity. It is important to estimate factors that impair referees' performance especially in the second half of a football match. There is limited research on the potential effects of mental fatigue on both physical and cognitive performance of referees.

#### METHODS:

Twelve (12) active football referees aged between 18-45 years (mean  $\pm$  SD: age  $32.3 \pm 10.0$  years) were recruited from Kent County Football Association (KCFA) to take part in the study. The referees were required to visit the laboratory on three separate occasions: a familiarisation (visit 1) and two main trials (control and mental fatigue, visits 2 and 3). Referees were required to perform a 90 min intermittent treadmill protocol after 30 min of a Stroop task: either incongruent (mental fatigue condition) or congruent (control condition). They were required to undertake the FIFA video clip test (decision-making) at the beginning (during warm-up: 13 min) and end of exercise (last 13 min). Exercise was an intermittent test which lasted 90 min in total. Heart rate, RPE and blood lactate measures were recorded before, during and after exercise. Referees also completed the PVT before and after the Stroop task, at half time and post-exercise, and the Brunel Mood Scale (BRUMS) before and after the pre-match PVT and after the post-match PVT.

#### RESULTS:

The mental fatigue condition caused a significant decrease in decision-making performance (correct decisions, beginning:  $76.7 \pm 7.2\%$  decreased to end exercise:  $64.6 \pm 7.8\%$ ,  $p < 0.001$ ) compared to no change in the control condition). The PVT performance was also significantly reduced post-Stroop test, at half time and post-exercise, but to a greater extent in the mental fatigue condition ( $p < 0.05$ ).

#### CONCLUSION:

mental fatigue had a negative impact on referees' cognitive performance during and after exercise. This may have implications for optimising referees' preparation and cognitive performance in real matches, which should be explored further.

### ASSOCIATIONS BETWEEN PHYSICAL FITNESS AND DEPRESSIVE SYMPTOMATOLOGY IN OLDER PEOPLE: THE EFICCOM PROJECT.

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**INTRODUCTION:** Depression is one of the leading global causes of morbidity and disability. The depressive symptomatology in the elderly increases due to brain aging. Scientific evidence shows that a high level of physical fitness seems to have positive effects on elderly people with depression, but it should be studied at different depressive symptoms levels and population groups. Therefore, the aim of this study was to examine the associations of a set of physical fitness components (i.e., cardiorespiratory fitness, and muscular strength) with depressive symptomatology in older people at risk of mild cognitive impairment. **METHODS:** This study included cross-sectional baseline data from the EFICCOM project (Clinical Trial registration: NCT03923712). A total of 89 older people at risk of mild cognitive impairment ( $68.9 \pm 2.9$  years, 40 women) participated in our study. Cardiorespiratory fitness was assessed by the 6 minutes walking test (meters), while muscular strength was evaluated by handgrip (kg), arm curl (repetitions in 30 seconds) and 5 repetitions-chair stand tests (seconds). Depressive symptomatology was evaluated by Geriatric Depression Scale (GDS-15). Linear regressions analyses were applied after adjusting for basic confounders (i.e. age, sex, and antidepressant medication). **RESULTS:** Cardiorespiratory fitness ( $\beta = -0.141$ ,  $p < 0.001$ ) and muscular strength ( $\beta = -0.139$  for handgrip;  $\beta = -0.156$ , for arm curl and  $\beta = 0.104$  for chair stand; all  $p < 0.001$ ) were significant associated with depressive symptomatology. **CONCLUSION:** Cardiorespiratory fitness and muscular strength were inversely related to depressive symptoms in older people at risk of mild cognitive impairment. Our findings may suggest the need for improve or maintain the physical fitness due to the relationship with depressive symptoms.

### LEISURE-TIME PHYSICAL ACTIVITY AND PREVALENCE OF PERCEIVED OCCUPATIONAL STRESS: A CROSS-SECTIONAL STUDY AMONG JAPANESE WORKERS

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#### INTRODUCTION:

Some studies report that there is an inverse relationship between leisure-time physical activity (LTPA) and the prevalence of perceived stress. However, limited data are available on this relationship among Japanese workers.

We conducted a cross-sectional study to investigate the relationship between LTPA and the prevalence of perceived occupational stress among Japanese workers.

#### METHODS:

Participants were 5,988 Japanese men [median age 44 years] and 1,459 women [median age 42 years] who completed a self-administered questionnaire on their health habits, including LTPA excluding walking (never, only specific seasons, 1-2 times per month, once a week, more than twice a week) in 2017. Participants were classified into 5 groups based on their LTPA. The prevalence of perceived occupational stress was obtained using the Brief Job Stress Questionnaire. Multivariable-adjusted odds ratios and 95% confidence intervals for the prevalence of occupational stress were obtained using logistic regression models while adjusting for several confounding factors.

#### RESULTS:

874 participants had perceived occupational stress. Using the never LTPA group as reference the multivariable-adjusted odds ratios and 95% confidence intervals were 0.80 (0.60-1.07) for only specific seasons group, 0.81 (0.64-1.03) for 1-2 times per month group, 0.75 (0.59-0.96) for once a week, and 0.60 (0.47-0.78) for more than twice a week, respectively (P for trend  $< 0.001$ ).

#### CONCLUSION:

In this cross-sectional analysis, the results suggest that there is an inverse relationship between LTPA and the prevalence of perceived occupational stress among Japanese workers.

## IDENTIFICATION OF SOCIOCULTURAL BODY IMAGE PRESSURES AND ITS RELATIONSHIP WITH EATING DISORDER SYMPTOMATOLOGY AMONG ELITE ATHLETES

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It has been detected how athletes are exposed to a double body image and body weight pressure. Firstly, the sociocultural one; and secondly, the sport one, all of them focused on achieving a weight, a size and a body shape. In this line, an increase in sociocultural pressures has been detected among athletes. The tripartite influence model (Thompson et al., 1999) posits that three social influences (peers, parents, and media) are prompters and transmitters of the cultural values of physical appearance and have a direct impact on body dissatisfaction as well as an indirect impact through two variables: internalization of the social ideal body type and appearance comparison. The aim of the present study was to examine the sociocultural pressures that elite athletes perceived according to gender, sport groups and competitiveness level; and its risk to develop eating disorders symptomatology.

Participants were 646 elite athletes, 316 male [Mage= 16.93; SD= 4.70] and 330 female [Mage= 16.47; SD= 3.98], competing in 33 different sports. Subjects were recruited from four sources: the Center of Training and High Performance (CEARE), the Sports Program for Catalonia (Pla de Tecnificació Esportiva), the Center of High Performance (CAR) or clubs playing in top-level competition. They were asked to complete an online self-reported questionnaire containing several sociodemographic items, the Sociocultural Attitudes Towards Appearance Questionnaire (SATAQ) and the Eating Attitudes Test (EAT-26).

Results showed significant differences between males and females in the internalization of a muscular body subscale ( $U= 42822.500$ ,  $p < .001$ ) with higher scores among males; in the internalization of a thin body subscale ( $U= 40793.500$ ,  $p < .001$ ) with higher scores among females; and in the peers subscale with higher scores among males ( $U= 43576.000$ ,  $p < .001$ ). No significant differences were found between male athletes according to the type of sport and to the level of competition. However, there were significant differences between female according to the type of sport ( $\chi^2(5)= 25.46$ ,  $p < .001$ ) and to the level of competition ( $\chi^2(3)= 9.59.46$ ,  $p < .05$ ).

Regarding relationship between sociocultural body weight pressures and eating disorder symptomatology, significant differences were found in all SATAQ-4 subscales between females who score below and beyond the cut-off point of the EAT-26, whereas differences between males who scores below and beyond the cut-off point of the EAT-26 were found also in all SATAQ-4 subscales except in the media subscale.

The present study findings are in line with previous studies, which indicated that, the thin-ideal internalizations and appearance pressures can be related to body dissatisfaction and consequently they play as a risk factors influence for disordered eating among male and female athletes. These results must be considered to educate sport professionals, and to prevent and cope body image and body weight pressures in athletes.

## OP-SH03 Coaching and physical education

### ANALOGY LEARNING STRATEGY IN SMALL SIDED GAMES

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The analogy learning strategy arises with the intention of reducing the amount of information that is consciously processed by administering a single explicit instruction in the form of a metaphor or biomechanical information unit, encompassing several rules in one and thereby omitting the step Declarative of learning, associated with the preparation, control and correction of movement, based on the conception that a

greater number of rules in working memory increases the mental workload, and therefore hinders performance.

The studies carried out that have tried to verify the benefits of this strategy in basketball have mainly focused on the throw to the basket from the free kick. We carried out an extension of the use of said learning strategy in the field shots carried out during the development of reduced tasks of a specific game.

Objectives: To analyze the effect of the learning strategy by analogy on the performance of the throw to the basket in basketball.

Design: An intra-subject design with repeated pre-test and post-test measurements has been elaborated on a reduced 2x2 collective game situation with a time limit.

Method: Twelve participants belonging to a mens basketball team aged between 13- 14 years ( $M = 13.58$ ;  $\pm 1.78$ ) with less than 6 years of basketball practice. 3 groups were carried out randomly: group learning by analogy (1 rule), group explicit learning (4 rules) and control group.

Results: The group of learning by analogy obtains better results in the launch to the basket than the explicit group and control during the development of the tasks carried out, also making better decisions during the game. Furthermore, in retention tasks it is the learning group by analogy that obtains the best results.

Conclusions: In general, we can affirm that offering players a lower number of rules for learning to throw to the basket benefits performance, since it increases the processing capacity available to other processes for players, thereby benefiting decision-making.

### TACTICAL FENCING PROFILE: ELITE ÉPÉE MEN'S & WOMEN'S

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#### INTRODUCTION:

The objective was to determine the effectiveness of elite female and male épée fencers based on the initiative of attack, the pressure and the piste area

#### METHODS:

A non-participant observation with a nomothetic, punctual & multi-dimensional design (Anguera, 2011) was used. 15 male épée (ME) and 15 female épée (FE) combats ( $n=32$ ) were recorded during the World Championships 2014. ESGRIMOBES (Tarragó, 2015) and Lince (Soto, 2019) were utilised as an observational and recording instruments. The fencer who made the first attack is "A" and his rival "B". It was analysed "A" pressure (Pres\_A), "B" pressure (Pres\_B) or not obvious pressure (N\_Pres). The piste zones: (End\_A & End\_B) are 2m's at each

end, and the rest is the centre (Central). The effectiveness is determined as A\_Touch, B\_Touch, Double or dont touch. The differences in the distribution were checked with chi-square.

RESULTS:

1598 actions were analysed. 36.7% were Pres\_A, and 22.6% were Pres\_B, while 40.7% were N\_Pres. There is no relationship between pressure and effectiveness (n.s.) in total records.

In FE (n=759), Pres\_A achieves in 19.4% A\_Touch, 10.3% B\_Touch and 9.5% Double. Pres\_B gets 20.6% A\_Touch, 20.0% B\_Touch and 7.5% Double. With N\_Pres you get 16.9% A\_Touch, 9.0% B\_Touch and 7.0% Double (p=.008).

In ME (n=839), Pres\_A achieves in 14.1% A\_Touch, in 16.2% B\_Touch and in 7.2% Double. Pres\_B achieves 17.2% A\_Touch, 11.2% B\_Touch and 5.1% Double. With N\_Pres you get 7.5% A\_Touch, 16.9% B\_Touch and 35.2% Double (n.s.).

In ME, in Pres\_B, "A" manages to touch more than "B" both in the End\_A (18.9% vs. 13.5%) and in the centre (16.8% vs. 9.8%)(n.s.). The best options for B\_Touch are with Pres\_A in the central zone (15.8%; 9.6%)(p<.001). However, in FE (n.s.), this tactical option is not exploited by "B", since "A" achieves greater effectiveness (17.7%) than "B" (10.7%). In N\_Pres, 99% of actions are in the central zone, with values of 16.7% and 17.2% in ME(p=.011) and FE (n.s.) respectively, in relation to 9.1% and 12.7% of B\_Touch.

With Pres\_A the highest effectiveness of the A\_Touch occurs in the End\_B zone (29.7%) in FE (n.s.) and ME (25.5%;p =.001).

CONCLUSION:

Delhomme (2016), defines 4 tactical profiles according to the fencer who makes the decision to attack and apply pressure. Individual study is very appropriate. In our case we have collectively valued the 16 best in the world, which gives us more global information but less precision individually.

The combination of pressure factors and piste area determine the effectiveness. The most effective situation for the attacking épée fencer is to attack after pressuring his opponent at the end of his opponents piste.

Grants: Study supported by PGC2018-098742-B-C31 (Spain)

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**LEVEL OF ACHIEVEMENT OF THE GRADUATE PROFILE OF UNDERGRADUATE FOURTH YEAR STUDENTS OF THE PHYSICAL EDUCATION CAREER AT THE CATHOLIC UNIVERSITY OF MAULE**

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Level of achievement of the graduate profile of undergraduate fourth year students of the physical education career at the Catholic University of Maule

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Introduction

Evaluating the graduate profile declared by a university implies a challenge. It is compulsory to clarify questions concerning the learning area in Physical Education: what type of knowledge do students acquire? (Gallardo et al., 2018) which is the level of mastery of the learned contents? (Hortigüela et al., 2018) which competencies are achieved? And which evidence is presented to assure achievement of graduate profile? (Castejón et al., 2018)

Methods

The study objective is to verify the achievement level of the fourth-year students' graduate profile from P.E. UCM-Chile. The sample consisted of 60 students of which 39 are men and 21 women. An instrument was used to evaluate specific disciplinary knowledge declared by the physical education and health education curricula of Chile which considered seven areas knowledge: Expression, Didactics, Management, Training, Sports, Recreation and Health and First Aid, with a total of 70 items. For the analysis of the graduate profile, the subjects that were tributary to the graduate profile were defined according to the dimensions proposed by González et al., (2019)

Results and discussion

The results indicate that, although the students show reaching the declared graduate profile, there are areas of the curriculum that are descended, i.e. motor expression in which men appear more descended than women in Health and First Aids in which, both men and women are under 50% of those expected with equivalent percentages 46%, the highest performances are concentrated in Didactics and Recreation. At the same time, it is concluded that in all the dimensions more than 70% of the students is between the basic, medium and advanced levels respectively, similarly to what was found by González et al., (2019)

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**GOVERNANCE AND LEGITIMACY IN COLOMBIAN ASSOCIATED SPORT**

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Introduction

From the studies of the Play the Game organization in 2015 with 35 international sports federations, Colombia was interested in determining the state of governance and legitimacy of National Sports Federations; research developed by the University of Applied and Environ-

mental Sciences U.D.C.A, with the support of the Colombian Olympic Committee and the Ministry of Sports. Colombia, for its results in the Rio 2016 Olympic Games, within 206 countries was ranked 23rd; which attracted attention, generating the following questions: Which is the Colombian institutional design that has favored these sporting achievements? Does the management model favor the good governance in Colombian sports federations?

#### Method

The population corresponds to 19 sports federations of the Olympic program in which Colombia competed in Rio 2016, of which 8 Federations was evaluated applying the instrument called Sports Governance Observer [1], which had to be adapted to the Colombian institutional model and was structured over 4 dimensions and 34 indicators. The study was carried out with the Federations, developing the Principal - Agent model, where the main ones were: Colombian Olympic Committee, Ministry of Sports, sports leagues, sports clubs and athletes.

#### Results

The governance index for Colombia was 51.4%, for each federations was observed the results were: equestrian 30%, fencing 44.8%, taekwondo 46.34%, football 50%, cycling 56%, athletics 57%, tennis 59% and golf 68%. Regarding the rating index of the dimensions, they were: transparency 54%, democratic processes 76%, separation of powers 60% and solidarity 56%, finally, the qualitative qualification was perceived as moderate; by a Likert scale of 1 - 5.

#### Discussion

The qualification obtained in the dimension of democratic processes is a result to the Colombian institutional design, which is the product of a norm established in 1995. The Principal - Agent model is fundamental to determine the chain of delegation of responsibilities from the Principal to the Agent [2]. Elgie (2011) established that the principals expect that the agents behave appropriately in each dimension evaluated. In the Colombian case, the delegation of the club to federation than of the league to federation has been more effective, as in the case of Golf, whose federation is made up of clubs; clarifying that, in the Colombian institutional design, there are other federations constituted by leagues.

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## OP-SH04 Gender: Sport and physical education

### A COMPARISON OF ACTIVITY LEVELS OF GIRLS IN SINGLE-GENDER AND CO-ED PHYSICAL EDUCATION

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Participation in physical activity benefits both physical and mental health through weight management, increased mood and stress control (Chalkley et al, 2015; World Health Organisation, 2015); however evidence suggests that the majority of people throughout the developed world are not physically active enough to reap these benefits (Niblett, 2016; Hallal et al, 2012). Furthermore, these levels decrease with age, especially for females (Niblett, 2016; Brown et al, 2015). Adolescent females are of key concern as a World Health Organisation (2015) survey found that more than 86% of 15 year old girls are physically inactive. The National Agency for Sport have identified age 12 as a key drop out stage for girls in Scotland (sportsScotland, 2004) and the Scottish Health Survey (Brown et al, 2015) reports that where 72% of boys aged 13-15 reach the recommended guidelines for physical activity, only 53% of girls do.

This study examined whether single-gender or mixed-gender PE lessons were more conducive to increasing the physical activity levels of girls. One hundred and twenty girls (12-15 years) wore a wGT3x+ActiGraph accelerometer while participating in basketball games. Time spent in low (LPA), moderate (MPA), vigorous (VPA) and moderate-vigorous physical activity (MVPA) were compared between a single-gender and mixed-gender PE lesson. Perceived effort and enjoyment of each lesson were also captured using a three-point scale following the intervention. Girls were found to spend significantly more time in MVPA ( $p=0.01$ ) and VPA ( $p=0.006$ ) in the single-gender environment. Furthermore, girls spent significantly less time in LPA ( $p=0.014$ ) in the single-gender session. When asked about perceived effort the girls stated that it did not alter with the addition of boys, however they did show a preference for taking part in a single-gender environment. Results of this study suggest that segregating PE classes for game-based activities could lead girls to achieve greater health benefits through a higher level of activity.

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### A QUALITATIVE ANALYSIS OF FEMALE RUGBY COACHES' LIVED EXPERIENCES OF COACHING AND COACH EDUCATION IN THE UNITED KINGDOM AND IRELAND.

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#### Introduction

Women's rugby union is one of the fastest growing team sports in the world, with the sports' governing body, World Rugby, reporting a significant increase of 28% of registered female players since 2017 (Kanemasu & Johnson, 2019). Despite the increase in playing numbers there is an underrepresentation and decline of females in coaching positions for both female and male teams, a long-known and well-documented problem (Acosta & Carpenter, 2014; LaVoi, 2017). This underrepresentation is most notable in rugby union within the UK and



Ireland and is present across all levels from grassroots to elite domains. This study investigated female coaches' lived experiences of coaching rugby and the rugby coach education pathways in the UK and Ireland with a view to understanding why this underrepresentation exists.

**Methods**

Twenty coaches (age 20-48yrs) with a range of coaching experience (3 to 15 years) participated in the study. All coaches were National Governing Body (NGB) accredited to a minimum Stage Two (2) and held either an assistant or head coaching role. Data was collected through semi-structured interviews (45-90 min, mean 55.8 min,  $\pm 17.22$ ) and were transcribed verbatim. Interpretive Phenomenological Analysis protocols were employed, allowing for effective interpretation of the participants' perceptions therefore recognising key areas of their lived experiences.

**Results**

Socio-cultural issues remain key influencers in rugby union. Barriers still exist, such as traditionalist attitudes, low self-belief and lack of opportunities, that prevent women entering rugby coaching. However, the coaches identified the coach education system as inclusive and proved beneficial in supporting their development.

**Discussion**

Recommendations to support female coaches identified an early introduction of a mentor, more female educators and contextualising the course content to offer an interpersonal approach to meet individual coaching needs. Greater presence in, and support from, all media will also help to promote females as coaches.

Further recommendations suggest that merely asking females to become involved at every level of the game would contribute to the reduction of the existing underrepresentation. This research may help to support and improve NGB coach education programmes whilst providing a foundation framework to support future research into women's rugby.

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**OVERCOMING GENDER BARRIERS IN SPORTS – AN OPPORTUNITY OF ADVENTURE/HIGH-RISK SPORTS?**

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**INTRODUCTION**

Although female sport participation has increased over the last decades, sport is still a male domain. One of the reasons for girls to withdraw from sports is their fear of crossing gender boundaries [1]. This is particularly present in sports comprising male attributes [2]. Despite adventure/ high-risk sports (AHRs) comprise many male attributes, they were developed in a different social context and are unlike most traditional sports, usually not separated by sex. Thus, the aim of the following study is to compare women from traditional sports with women from AHRs regarding their experience of possible advantages and disadvantages in their sports.

**METHODS**

10 female alpine climbers (AC; mean age: 26 years, mean sport experience: 12 years) and 10 female soccer players (SP; mean age: 31 years, mean sport experience: 21 years) were interviewed about their gender related sport experiences following a semi-structured interview guide. Interviews were analysed with an inductive approach using MAXQDA Software.

**RESULTS**

Differences between AC and SP were seen in statements regarding advantages and disadvantages of female sport participation and in terms of received prejudices towards their participation. Whereas performance related male advantages were named as physical strength (SP 70%/AC 70%), higher courage and risk taking (AC 80%), higher participation numbers (SP 40%) and lower starting age (SP 40%), AC (60%) spoke of higher technical abilities in females in order to compensate for missing strength. A more cautious approach by woman was named as another female advantage (AC 70%). SP (30%) mentioned a less theatrical game compared to men in terms of received fouls as a female performance related advantage. The vast majority of SP (80%) but only 30% of AC spoke about barriers when starting with the sport. Most mentioned barriers were negative comments which degraded female sport participation. SP also spoke about disadvantages compared to men in terms of training and tournament hours, sponsorships by the club and in terms of a need to feminise themselves for shootings or as members of the first league. When asked about their team members, 80% of AC climb with male partners, whereas 80% of SP only play with women. SP and AC perceived their sport as either male (SP50%/AC 40%) or indifferent (SP50%/AC 60%).

**DISCUSSION**

AHRs participants seem to experience a more gender balanced sport participation. AC could mention more performance related female advantages and reported fewer barriers towards sport participation than SP. Since ACs climb with more male partners and need to trust each other in order to be a successful climbing team, gender might play a minor role in AHRs.

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**GENDER EQUALITY AND LEADERSHIP IN INTERNATIONAL SPORTS FEDERATIONS**

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A growing number of studies on the representation of women in sport governance have been conducted in recent years. Studies mainly focus on a specific country, such as the Netherlands (Claringbould & Knoppers, 2007, 2008, 2012), Norway (Hovden, 2010, 2012; Sisjord & al., 2017), or Germany (Pfister & Radtke, 2009). Studies analysing international sport organisations remain rare and international sports federations (IFs) remain a "black box" regarding this issue.

To fill this gap in the literature, this study proposes an overview of the current women's participation in the decision-making bodies of Olympics IFs. It first uses a quantitative approach: it gathers evidence on IFs' board composition as well as on the IFs' leadership duo president/director general. In a second step, we have conducted an exploratory study at the International Cycling Union (UCI), consisting of 12

semi-structured interviews: six with women and six with men from different hierarchical levels (president, directors, heads/chiefs of department, managers, coordinators).

Our results show that despite a positive evolution in general, women holding leadership positions in the governance of key sport organizations remain an exception. The study further suggests that the gender orientation of a sport, the history of the federation's structuration as well as the formal gender policies implemented by the organizations impact the gender ratio at governance level. Using these findings, we conclude that female sport leaders at the international level continue to struggle in terms of overall representation and access to leadership positions.

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## OP-SH05 Motivation in sports

### AN INVESTIGATION OF THE QUALITY AND SAFETY OF WORK-INTEGRATED LEARNING PROGRAMS IN EXERCISE AND SPORT SCIENCES

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**INTRODUCTION.** Effective work-integrated learning (WIL) programs for students require access to safe and quality learning environments, preparation and support for supervisory staff, and establishment of appropriate risk management processes. However, knowledge on these aspects specifically in exercise and sport sciences (ESS) is lacking. The aim of this study was to analyse the quality of student WIL experiences in ESS and identify risks to their health and safety needs.

**METHODS.** An online survey consisting of four dimensions (Welcome and Belongingness, Teaching and Learning Support, Competence and Confidence, and Health and Safety Needs) rated using 5-point Likert scales was administered to second- and third-year ESS students and supervisors at a regional Australian university delivering both online and on-campus education. Data were collected upon the completion of work placements between September-November in 2018 and 2019. Data were analysed using descriptive statistics and non-parametric tests for correlations and differences between groups.

**RESULTS.** Overall, 27 students (26% response rate) and 33 supervisors (28% response rate) participated in the study. Most students studied online (74%, n = 20) and were located in Queensland (n = 18, 67%). Most supervisors were located in Queensland (76%, n = 25) and had ≥ 6 years (76%, n = 25) of industry experience. Spearman's analysis showed a significant correlation between the four survey dimensions and students' (rs = 0.42 - 0.75) and supervisors' (rs = 0.46 - 0.64) satisfaction with the overall quality of work placements (p ≤ .05). Welcome and Belongingness (4.48±0.77, 95% CI = 4.18, 4.79) at work placements was rated highest while support for Health and Safety Needs (3.62±0.88, 95% CI = 3.27, 3.97) was rated lowest by students. Kruskal Wallis tests showed that the support to meet Health and Safety Needs of students was significantly different (H(6) = 13.988, p = .030) across work placement organisations with a mean rank of 24.10 for community sport clubs, 21.50 for local government organisations, 14.75 for public schools, 12.33 for private health clinics, 11.71 for private health and fitness centres, and 9.90 for public health and fitness centres.

**CONCLUSION.** Most students and supervisors were satisfied with the overall quality of work placements. However, it is worrisome that the support to meet health and safety needs of students at many work placement organisations was suboptimal. These findings warrant future research to investigate support needs of students and identify appropriate risk management strategies that can be utilised by the universities, work placement organisations, and supervisors to minimise WIL related risks to the health and safety of students.

### AUTONOMOUS MOTIVATION TO REDUCE SEDENTARY BEHAVIOUR IS NEGATIVELY ASSOCIATED WITH SITTING TIME AND INFLAMMATORY DISEASE ACTIVITY IN RHEUMATOID ARTHRITIS: A LONGITUDINAL STUDY

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**INTRODUCTION:**

Rheumatoid Arthritis (RA) is an autoimmune disease characterised by chronic, systemic and synovial joint inflammation, leading to joint erosion and pain, as well as increased risk of cardiovascular disease. Since evidence suggests sedentary behaviour (SB; such as sitting time) relates to increased inflammation, SB may hold implications for the inflammatory burden of disease in RA. Research investigating; 1) the role of SB for RA disease activity, as well as 2) potential determinants of SB in RA (for targeting in subsequent intervention), is therefore warranted. Moreover, as studies suggest higher levels of physical activity (PA) associate with reduced inflammation in RA, and SB and PA are inversely correlated, the link between SB in RA should be examined in concurrence with PA.

**AIM:**

This longitudinal study tested a Self-determination Theory-based model of behaviour (Deci & Ryan, 1985), to examine whether changes (baseline to 6-months) in autonomous and controlled motivation to reduce SB (hypothesised determinants) were associated with changes in SB and PA, and in turn, change in inflammatory RA disease activity.

**METHODS:**

RA patients (n = 52) undertook assessments at baseline (T1) and 6-months later (T2). At each time point, participants completed a questionnaire assessing their autonomous and controlled motivation to reduce SB (Behavioural Regulation in Exercise Questionnaire-2, adapted

for reducing SB). Routine clinical assessments were conducted to determine; 1) systemic inflammation (C-reactive protein (CRP, mg/l), and 2) RA Disease Activity Score-28 (DAS-28; swollen/tender 28-joint count + Erythrocyte Sedimentation Rate + self-reported global health). Daily time spent sitting and stepping were measured over 7-days via the activPAL. Path analysis was employed in conjunction with bootstrapping (2000 samples, 95% CI) to test the hypothesised model (i.e., change (T1 to T2) in autonomous/controlled motivation > change in sitting/stepping time > change in CRP/DAS-28)

**RESULTS:**

The model demonstrated an excellent fit to the data ( $X^2(5) = 5.7$ ,  $p = .34$ , CFI = .99, RMSEA = .05 (PCLOSE = .41, 90% CI [.00 - .21])). Autonomous motivation to reduce SB significantly negatively predicted sitting time ( $\beta = -.43$ ) and significantly positively predicted stepping time ( $\beta = .32$ ). In turn, sitting time significantly positively predicted CRP ( $\beta = .38$ ) and DAS-28 ( $\beta = .30$ ), but no significant associations were observed between stepping time and these outcomes (CRP,  $\beta = -.14$ ; DAS-28,  $\beta = .04$ ). Autonomous motivation was also significantly, negatively related to CRP ( $\beta = -.19$ ) and DAS-28 ( $\beta = -.12$ ), indirectly via sitting time. Controlled motivation did not predict sitting or stepping time (both  $\beta = .01$ ).

**CONCLUSION:**

Reducing SB associates with beneficial changes in inflammatory disease activity in RA. In addition, autonomous motivation to reduce SB may represent a modifiable, and effective target for interventions targeting SB in RA, to the extent required to reduce the inflammatory burden of Rheumatic disease.

**THE DUAL COMMITMENT OF STUDENT-ATHLETES IN LOWER SECONDARY SPORT SCHOOLS.**

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**Introduction**

Young athletes are expected to simultaneously succeed with in school and sport. However, some athletes struggle to find a proper balance between combining an athletic career with an academic career. Although education is perceived as important by student-athletes, sport comes first for many athletes. Importantly, these findings mainly come from upper secondary and university students, while research on younger adolescent student-athletes has been largely overlooked.

**Methods**

This presentation is part of a larger study of a 3-year Olympic Committee project. The Finnish Lower Secondary Sports Schools Pilot Project has 19 schools from all parts of Finland. Drawing upon rich qualitative data derived from individual interviews with student-athletes involved in individual and team sports in grade eight ( $n = 15$ ), teachers ( $n = 4$ ), principals ( $n = 2$ ), and nonparticipant observations from academic classroom lessons ( $n = 5$ ) and practice sessions ( $n = 7$ ) at five schools, this paper examines how young student-athletes succeed in school, sports and in combining these two. A semi-structured interview schedule was based on the literature including previous questioning guides used in dual career research with high school and university students. The data was analyzed using inductive thematic analysis to find themes describing these student-athletes. The credibility and trustworthiness of the analysis was ensured through data triangulation using multiple data sources, peer debriefing, thick description and participant quotes.

**Results**

The main findings indicated that most student-athletes had high ambitions and showed a strong orientation in their school approach. For some student-athletes, the student and athlete role was conflicting and they prioritized sport over educational success. However, most student-athletes were successful in school, although some male student-athletes had less focus on school achievement. A similar variation in student-athletes' sport commitment was found; from having a goal to become a professional athlete to pursuing sport as a leisure activity. The school path, including upper secondary and university studies, was also seen as a backup and security for future decisions. Finally, the sport school provided more opportunities for practice and also a flexibility in school related issues.

**Discussion**

The findings indicated the multi-faceted nature of the dual commitment of student-athletes in lower secondary sport schools. Consequently, it is difficult to form a consistent picture that fit every context because the student-athlete role is individual and to some extent conflicting. Importantly, this knowledge need to be used to inform the government and the sporting movement to draw up, develop, and implement a dual career program, however, in close cooperation with local lower secondary schools.

**ANTECEDENTS OF PE TEACHERS' MOTIVATIONAL STRATEGIES**

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UNIVERSITY OF PHYSICAL EDUCATION

**Introduction**

Limited research has addressed the causes of, or reasons for, PE teachers' adoption of particular motivational strategies. Previous work by Taylor and colleagues (Taylor & Ntoumanis, 2007; Taylor, Ntoumanis & Smith, 2009; Taylor, Ntoumanis & Standage, 2008) has identified several correlates through qualitative and cross-sectional studies. These studies were grounded in Self-Determination Theory. Cross-sectional and longitudinal research has also been conducted by Stebbings and co-workers (Stebbing, Taylor & Spray, 2011, 2012, 2016; Stebbings, Taylor, Spray & Ntoumanis, 2012) with sports coaches to identify the predictors of autonomy supportive and controlling behaviours toward athletes.

The aim of the present study was to obtain information on perceived job pressures (time, school/colleagues, student performance), teacher perceptions of student self-determination and teachers' autonomous causality orientation. These three predictors were hypothesised to link with specific teachers' strategies of gaining understanding of students, giving instrumental help and support, and providing meaningful rationales. The proposed mediators were teacher need satisfaction and self-determined motivation for work.

**Methods**

Sixty-eight Slovakian PE teachers, from both primary and secondary schools, completed five questionnaires. Data collection instruments comprised seven-point Likert scales regarding (1) the teaching environment (job pressures and professional development), (2) teachers' perception of students' motivation, (3) basic psychological need satisfaction of teachers at work, (4) teachers' motivation, and (5) teachers' teaching style. Data were analysed in IBM SPSS v. 25 software package.

**Results and Conclusions**

Male teachers perceived more autonomy satisfaction ( $p = 0.027$ ) than female teachers. Those PE teachers, who worked with older students (upper primary and secondary school) perceived higher general job pressure ( $p = 0.001$ ) and job pressure from being evaluated ( $p = 0.049$ ), as

opposed to teachers who worked with younger students (in lower primary schools). In addition, teachers working in 12-year comprehensive schools perceived higher job pressure from being evaluated ( $p=0.026$ ) than those teachers who worked in lower primary schools. Teachers were also compared by age as well as teaching experience. Results demonstrated that younger teachers, as well as less experienced teachers, perceived higher level of general job pressure than older and more experienced colleagues (both  $p=0.012$ ). No significant differences were found for teachers' motivation, perception of students' motivation and teaching styles. In conclusion, Slovakian teachers demonstrated self-determined motivation in their job, and perceived their students to be autonomously motivated in PE. However, schools should consider strategies in order to deal with teachers' job pressures. These potential arrangements should promote good quality and motivated staff members for the future.

## OP-SH06 Social media and Social Inclusion

### WHY DO STUDENTS PLAY SPORT? – LONG TERM CHANGES OF FACILITATING AND HINDERING FACTORS OF REGULAR SPORT ACTIVITIES OF HUNGARIAN UNIVERSITY STUDENTS

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Almost 9 years ago we investigate – by the online sample of 17,000 students and by the representative sample of 1,500 young adults with personal interviews – the students' sport habits in Hungary. At that time only 23.1 percent of students said doing sport at the evidence based minimum level of WHO criteria, specified at least 2-3 times a week for minimum 30-45 minutes per occasions. On the other hand, there was a significantly different patterns of the facilitating and hindering factors of sport of man and woman students.

In the last decade in Hungary the sport was one of the strategically supported sectors. Most of the multiplying state budget of sport are focused on the 16 prioritised sports and on the six team sports benefited from a tax relief system. Although the university sport was not a highlighted field, however there was some development as the trickle-down effects mostly in the competitive sport, but also in the sport for all efforts of universities.

To explore the impact of the interventions we conducted a same research in a representative sample of almost 7,000 students with cooperation of Educational Authority of Hungary. Our repeated questionnaire was the supplementary of the Hungarian part of Eurostudent VII project – controlled by the European Commission and the European Student' Union – which provides a broad, policy-relevant cross-country comparison of data on the social dimension of European higher education.

One of the most relevant results is the motivational background of sport habits. There are significant and heavy gender differences in the patterns, e.g. the popular man and woman sports, or the main facilitating factors. Become more and more rich answers of students about causality of sport activities. The research pointed out the strong connection between the frequency of regular sport and the importance of health. The losing of shallow excuse: "I have no time!" is less appropriate. At the same time, the external definiteness (e.g. good-looking) turn out to be more emphasised, but mostly the woman students clearly separate the competitiveness and personal recreational sport. Equally the basic and analysed data are a robust and policy-relevant source to prepare strategical changes in the filed of regular physical activities of students.

### "PASS THE BALL TO ME- BUT YOU WON'T GET IT BACK... " - UNDERSTANDING SOCIAL INCLUSION IN TEAM ACTIVITIES IN PHYSICAL EDUCATION

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UNIVERSITY OF AGDER

"Pass the ball to me- but you won't get it back... "

Understanding social inclusion in team activities in Physical Education

Introduction

Social inclusion is an important aspect of cooperation and for creating meaningful experiences in physical education (PE) (Beni, Fletcher, & Ní Chróinín, 2017). Cooperation is an important life skill which may be learned through team activities in PE (Goudas, 2010). Therefore, it is important to investigate the following research question; how is social inclusion experienced in PE? and examine how these experiences may facilitate learning of social inclusion as a life skill in team activities.

Methods

The study consisted of two classes (49 students) and their two PE teachers. Methods used in this article consisted of written narratives conducted at the end of the students 8th grade and after each of the 14 PE lessons in 9th grade, 20 interviews (19 students) from one class and two interviews of their teacher, and observation and video-recordings of the 14 PE lessons. The data creation was triangulated and thematic analysed through Nvivo11.

Results

The students had positive experiences towards social inclusion like "cooperating and helping each other", "passing the ball", and "working together", and negative experiences towards social exclusion like peers was "ruining the game for others", "keeping the ball to themselves", and "losing the ball". The students were motivated for speaking up against social exclusive peers in team activities and being social inclusive themselves. However, the students regarded it as difficult to influence their peers to become more inclusive. Further, the social interactions in team activities contributed to the maintenance of social exclusive behaviour. The teacher instructed students to include their peers in one activity, but the inclusion of peers did not transfer to the next activity.

Discussion

Findings indicate that teachers should take into consideration the following statements:

1. Learning of social inclusion should be employed within the team activities.
2. Creating an environment where positive feedback is given on social inclusion skills in team activities.
3. Organizing short activities where the teacher observes and analyse which action that should be done for creating better social inclusion.
4. Including the students in their learning processes of social inclusion skills.
5. Learning of social inclusion skills should be conducted in a concrete way.

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### "STEPPING OUT OF THE BOX" – A COMPARISON OF PETE- STUDENTS' ATTITUDES TOWARDS INCLUSIVE PE IN THREE EUROPEAN LOCATIONS

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#### Introduction

Alongside conceptual considerations on inclusive practices and structures (e.g. Booth & Ainscow, 2001), attitudes of PE-teachers are in the spotlight as the success of inclusive learning settings seems to depend strongly on them (Hutzler et al., 2019). Generally, attitudes count as influential variables in teaching design and should be considered in PETE (Darling-Hammond & Bransford, 2005). In addition, inclusion rates as well as cultures and traditions of PE differ in Europe. It seems obvious that efforts to promote inclusive PE(TE) face different challenges depending on which location is considered. Such challenges probably affect PETE-students' attitudes towards inclusive PE. Gaining knowledge of differences in EU-PETE-students' attitudes towards inclusive PE could be highly relevant for inclusive PE in future: to drive PETE forward, to develop PE on a conceptual level, as well as on the practical teaching level.

#### Methods

A framework was designed to assess and compare PETE-students attitudes towards inclusive PE. Based on qualitative pre-studies a quantitative specialist and requirement-specific test instrument was validated, which measures multi-dimensionally on a latent level (Meier & Ruin, 2019). With this instrument, the attitudes of PETE-students were recorded in Cologne (GER), Groningen (NE) and Coimbra (PO) (N=439).

#### Results

This comparison highlights visible differences between the three EU-locations. The Dutch PETE-students exhibit attitudes, which are more favourable to the global agenda of inclusion (not least characterized by a focus on individuality) compared to the Germans and Portuguese. The Portuguese instead, show a tendency towards narrow, and sport-oriented attitudes.

#### Discussion

Even if this small study can only be understood as a starting point, it reveals striking differences, which provide important approaches to develop inclusive PETE as well as PE in future. It already highlights the importance of working on international comparisons with various countries.

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### INVESTIGATION OF ENVIRONMENTAL IMPACTS ON UNIVERSITY STUDENT'S PHYSICAL ACTIVITY PARTICIPATION BY CROWD SOURCING METHOD IN MOBILE TECHNOLOGY

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Background: Physical inactivity has been identified as one of the leading global risk factors for morbidity and mortality. However, only 8.4% of Hong Kong youths meet the recommendations for physical activity (PA) of 60 minutes/day. Environmental factors have been found to be related to PA in youths. Despite research evidence in the past few decades, it is largely unclear how youths interact with the environment and what the barriers and facilitators are to their participation in PA. Given the high ownership and use of smartphones by youths, mobile crowdsourcing offers an ideal opportunity to better understand the impacts of environmental barriers & facilitators on youth's PA participation.

#### Objective:

To investigate the environmental impacts on university student's PA participation and stage of changes by crowd sourcing method in mobile technology.

#### Methods:

88 university students (63.6% males) aged 19-24 years were recruited through social media. Participants were requested to download the application (Movn ([www.movinganalytics.com](http://www.movinganalytics.com))). It is a smart-app that tracks the time people spend in PA. It allows people to set daily PA goals and can prompt them to meet their goals. Once downloaded, data are passively collected using native features from the phone, including accelerometer and GPS sensors. All participant data, including mobile sensor data was anonymized and stored on a secure server. Participant's environmental barriers/facilitators to PA was assessed by the Neighborhood Environment Walkability Scale (NEWS) (Saelens & Sallis, 2002). The questionnaire content included: types of residences, stores, facilities, access to services, streets, places for walking and cycling, neighborhood surroundings, traffic hazards, neighborhood safety, parking, cul-de-sacs, hilliness, physical barriers, and social interaction while walking (5-Likert scale from none (1) to very important All).

Results: Participants' time spent in PA was 455.36 min per day on average (male: 455.6 min, female: 454.78 min). In the past 30 days, 67.2% of the participants had 0 day that achieved daily PA goal (30 min daily), and 13.1% of them had 1-5 days that achieved daily PA goal. Regarding PA stage of changes, 80.7% had intention to do more PA in the next 6 months. The scores of participant's environmental barriers/constraints to PA were 495.01 in residential density, 3.60 in land use mix-diversity, 3.26 in land use mix-access, 2.96 in street connectivity, 2.87 in walking facilities, 2.84 in aesthetics, and 2.71 in traffic safety, respectively. Male (3.53) had lower score in land use mix-diversity than that in female (3.73), but had higher score in traffic safety that that in female (male: 2.78, female: 2.59). The regression analysis demonstrated no significant association between all study environmental factors and PA.

Conclusion: The present study suggests that there is no significant impact of environmental factors on university student's PA using crowd source information.

### THE EFFECT OF TWEETING VIDEO ABSTRACTS ON JOURNAL ARTICLE IMPACT – THE EUROPEAN JOURNAL OF SPORT SCIENCE STUDY

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#### Introduction

Science communication and knowledge translation is important for science and innovation. To communicate science and translate research, academic journals make use of social media platforms such as Twitter. Twitter offers journals an efficient and cost-effective means to reach, disseminate and engage with a large and diverse audience in real-time. To be effective, journals use different Twitter strategies to maximise the reach and impact of their articles. Recently and increasingly, journals are making use video abstracts to communicate their research articles. However, the effectiveness of this Twitter strategy on journal impact metrics is not clear. Therefore, the purpose of this study was to determine the effect of two different video abstract formats on journal impact metrics compared to only posting the title of the article. The European Journal of Sport Science (EJSS), a leading multidisciplinary sport science journal, was used to conduct the study.

#### Methods

A randomized case-controlled study design was used with 3 groups - animated video abstracts (AN), author-provided video abstracts (AU) and title-only (TO). Each group consisted of 14 articles matched for topic, study design and published within 3 months of each other (a total of 42 articles). Tweeting of each article was randomised and posted only once. Each post contained a link to the full-text version of the article on the EJSS website with the hashtag #sportscience. The intervention began on June, 24, 2019 and the last post was disseminated on Twitter on July, 31, 2019. The primary outcome measures were 7-day and 30-day article page views, article altmetric score, Twitter impressions, Twitter engagements and link clicks. Outcome measures between the 3 groups were compared using the Kruskal-Wallis test.

#### Results

Page views did not differ between groups after 7( $p=0.393$ ) or 30-days( $p=0.905$ ). After 7-days, AN received significantly higher altmetric attention scores, impressions (AN 3879±1784; AU 2221±997; TO 2328±900), media views (AN 827±813; AU 373±247) and media engagements (AN 49±59; AU19±11) than AU or TO. After 30-days, AN received significantly more altmetric attention scores, impressions (AN 4783±2438; AU 2539±1145, TO 2723±1163), engagements (AN 148.9±134; AU 51±16; TO 57±39), media views (AN 739±738; AU 387±252) and media engagements (AN 59±62; AU 22±11) than AU or TO. TO received significantly more link clicks than AU or TO after 7-days (AN 28±27; AU 9±6; TO 34±25) and 30-days (AN 34±33; AU 10±6; TO 36±26).

#### Conclusion

Articles posted using animated video abstracts resulted in a greater number of engagements, impressions and altmetric attentions scores compared to author-provided video abstract or title-only posts after 7 and 30 days. Interestingly, despite the effectiveness of animated video abstracts on journal metrics, title only posts received more link clicks. Based on the findings, we suggest using a combination Twitter strategies.

### EXPERIENCES OF TRANSGENDER AND INTERSEX INDIVIDUALS IN SPORT AND PHYSICAL EDUCATION

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#### Introduction

Sport participation has been acknowledged as a significant socializing agent for young people. Nevertheless, as for young people the dialogue across individual identities and the ways of being, particularly for lesbian, gay, bi-sexual, trans-, inter- or queer persons (LGBTIQ\*) people, may encounter sexual stigma within sport culture. Despite the potential implications of sexual stigma in their everyday lives, there is a lack of information regarding the experiences of LGBTIQ in sport and physical education (PE) (Anderson & Bullingham 2015; McCormack 2014; Osborne & Wagner 2007; Petty & Trussel 2017). So the purpose of this paper was to examine how the coming-out process for people who identified as trans- or intersex persons shaped the meanings and experiences of their sport engagement in physical education and sport.

#### Methods

Aligned with a constructivist grounded theory approach, intense interviews and biographical stories as a form of knowledge were conducted to examine the perspectives of six trans- and intersex men on these issues. In the content analysis categories were developed and emphasis was placed on the experiences these persons made in society, in sport, and in PE.

#### Results

Despite the evidence that homophobia seems to be declining in different countries and social fields, sexual stigma is omnipresent in the stories of this study. Based on the experiences, the interviewees focused on changes that could be made at various levels to make the future of sport and PE more inclusive to all individuals regardless their gender.

#### Discussion

Particularly their suggestions for PE which is taught in Austria in a gender-segregated way from the age of 10 years onwards, led to discussions on how to organize PE in a more inclusive and non-discriminatory way (including locker rooms, toilets, ...) and how to enable self-determination in school settings for all students.

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## **OP-SH07 Physical activity: Cognitive functioning**

### **ASSOCIATIONS BETWEEN FALL RISK AND COGNITIVE STATUS IN OLDER PEOPLE: THE EFICCOM PROJECT.**

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**INTRODUCTION:** In an increasingly aging population, the number of people over 65 is rising. Aging is generally associated with neuromuscular impairment, gait and balance disorders, loss of mobility and consequently an increased rate of falls and fractures. Falls are a significant cause of morbidity and mortality among older adults. Moreover, older adults with neurocognitive disorders have been identified as having a high risk of falling. Nonetheless, the relationship of rate of falls with neurocognitive disorders has been poorly studied. Therefore, the purpose of this study was to examine the association between fall risk and cognitive status in older people.

**METHODS:** This study included cross-sectional baseline data from the EFICCOM project (Clinical Trial registration: NCT03923712). A total of 81 older people at risk of mild cognitive impairment (range 65 to 75 years;  $68.94 \pm 3.01$  years, 38 women) participated and had valid data for the present study. Fall risk was assessed by the Efficacy Scale International (FES-I), being a score  $\geq 23$  used as indicator of high fall risk. To determine cognitive status, the Clinical Dementia Rating (CDR) questionnaire was used. A score  $\geq 1$  is generally considered indicator of risk of dementia. Binary logistic regressions analyses between 2 groups (low/high fall risk) and (no dementia/at risk of dementia) were applied after adjusting for basic confounders (i.e. age, sex, body mass index and educational years).

**RESULTS:** Participants at higher fall risk presented almost 5 times higher risk of dementia than those peers with lower fall risk (Odds ratio = 4.8,  $p = 0.011$ ) after adjusted for basic confounders.

**CONCLUSION:** Overall, our findings shed the light on the association between fall risk and risk of dementia in older people. Further studies with larger samples sizes should corroborate or contrast our findings.

**Key words:** Risk of Falls, Falls Efficacy Scale International, Risk of Dementia, Clinical Dementia Rating, Elderly.

### **AEROBIC FITNESS LEVEL MODULATES WORKLOAD CAPACITY FOR FASTER DECISIONS IN YOUNG ADULTS.**

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#### **INTRODUCTION**

Several studies have demonstrated better cognitive functions in individuals with higher level of aerobic fitness. However, little is known about how aerobic fitness level relates to workload capacity, a measure of the change in perceptual processing efficiency as workload increases. Workload capacity is important for cognition and daily functioning as it is positively associated with individuals' capability of efficiently processing and integrating information from multiple sources to deal with the high-workload environment. Thus, the present study aimed to examine whether aerobic fitness level is related to individual differences in workload capacity.

#### **METHOD**

Twenty young adults with higher level of aerobic fitness (high-fit group; aged  $21.15 \pm 2.48$  years;  $VO_{2max} = 58.69 \pm 6.20$  ml/kg/min) and 20 demographically matched lower aerobic fitness counterparts (low-fit group; aged  $22.45 \pm 1.28$  years;  $VO_{2max} = 42.54 \pm 3.19$  ml/kg/min) performed a redundant-target detection task. According to Systems Factorial Technology (SFT), workload capacity was assessed by comparing the processing efficiency when two targets were presented simultaneously to when only a target was presented alone. Note that the processing efficiency was quantified by the integrated hazard function. In addition, a functional principal component analysis (fPCA), which describes the workload capacity function using a small number of values, was conducted to emphasize the variation in capacity results across individuals and conditions.

#### **RESULTS**

Results revealed no group differences in mean reaction times (RTs) across task conditions. In terms of SFT, our visual inspection from the capacity functions showed that high-fit group is predominantly comprised of supercapacity individuals and exhibited larger capacity than the low-fit group. In line with our observations, the fPCA results revealed higher capacity in the high-fit group compared with the low-fit group for the earlier responses, while such difference was not found for the later responses. Moreover, the hierarchical regression model revealed a positive relationship between  $VO_{2max}$  and workload capacity when controlling for potential confounding variables including age, body mass index, and the Beck depression inventory score.

#### **DISCUSSION**

Novel to the current study was to provide a more comprehensive investigation of the cognitive benefits of aerobic fitness. We observed that aerobic fitness was positively related to workload capacity while making faster decision rather than making slower decisions. As a result, our data indicate that the beneficial association of greater aerobic fitness with workload capacity may change dynamically across response times, which may be ignored using the measures of mean RT. In conclusion, this study suggests that high level of aerobic fitness is important for cognitive health, even for individuals during their cognitive peak.

### **EFFECTS OF PHYSICAL ACTIVITY INTERVENTIONS ON LANGUAGE SKILLS IN ELEMENTARY SCHOOL CHILDREN: A SYSTEMATIC REVIEW**

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**INTRODUCTION:** Academic achievement improvement through physical activity (PA) promotion in children has recently generated considerable research interest. Increased PA levels in school children is gaining popularity in terms of its potential to improve overall physical and

cognitive children's health, boost academic performance, and mitigate the effects of a sedentary lifestyle, including obesity prevention. Moreover, recent research proposes that language processing is affected by human movement in both syntactic and semantic since language comprehension uses neural systems for perception and action (1). However, evidence on the effects of physical activity on language skills remains scarce and unclear. The aim of this study was to systematically review the effects of PA interventions on language skills in elementary school children.

**METHODS:** This systematic review was conducted following PRISMA Guidelines. We systematically searched relevant articles in PubMed, PsycINFO and Scopus from inception to January 2020. We included controlled studies that performed a PA intervention in elementary school children aged 5-12 and assessed at least one outcome related to language skills (e.g. reading, writing, spelling, vocabulary, fluency, comprehension or academic achievement) in mother tongue or foreign language. The Effective Public Health Practice Project (EPHPP) quality assessment tool for quantitative studies was used to evaluate the risk-of-bias.

**RESULTS:** Twenty-one studies met the inclusion criteria for the review. PA interventions included active breaks during the school time, classroom-based PA integrated or non-integrated with curricular content, physical education courses and PA interventions during extracurricular time. The duration of interventions ranged from a single exercise bout, to know the acute effects, to long-term interventions lasting up to 3 years. Studies investigated a variety of academic-related outcomes including cognitive functions (e.g. executive function), academic achievement (e.g. WIAT II or WRAT III test scores) and language skills (e.g. reading comprehension, vocabulary, spelling). However, only language-related measures were considered when analyzing and synthesizing results. Out of the 21 studies, positive overall effects of a PA intervention on language skills were found in 12 studies (57%) and neutral overall effects in 8 studies (38%). Only one study (5%) reported negative effects in language scores whereas it showed improvement in reading score. In a risk-of-bias assessment, 8 studies had low, 9 moderate, and 4 had a high risk of bias.

**CONCLUSIONS:** Evidence suggests that PA interventions may be an effective strategy to improve language-related skills in elementary school-aged children. However, these preliminary results are inconsistent and the effects of PA on numerous language skills (e.g. vocabulary, writing, spelling) remain to be elucidated.

**REFERENCES:** Casado, P., et al (2018). *Cortex*, 100, 40-51.

### **EFFECTS OF PHYSICAL ACTIVITY INTERVENTIONS ON NEUROCOGNITIVE FUNCTIONING AND ACADEMIC PERFORMANCE IN ADOLESCENTS AND YOUNG ADULTS: A META-ANALYSIS.**

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#### **INTRODUCTION:**

Physical activity is associated with positive health benefits, and has been shown to exert beneficial effects on neurocognitive functioning and academic performance in elderly and preadolescent children, both after acute (one bout of exercise) and chronic physical activity (more than one bout of exercise). However, relatively little is known about the effects of physical activity on neurocognitive functioning and academic performance in adolescents and young adults. It has been argued that physical activity might be beneficial for the proliferation of higher cortical functions, the so-called executive functions, that show rapid development during this stage of life. The aim of the present meta-analysis was to aggregate the results of intervention studies investigating the effects of physical activity on multiple domains of cognitive function and academic performance in adolescents and young adults (12-30 years of age).

#### **METHODS:**

The electronic databases Web of Science, Medline, Embase, Eric and Psycinfo were searched to locate relevant studies using keywords related to exercise interventions, cognitive function, academic performance and adolescents or young adults. Eligibility criteria for selecting studies were: (a) the use of a controlled study design, (b) investigation of the effects of physical activity interventions (with at least a sports or exercise component) on neurocognitive function (processing speed, attention, executive function) or academic performance; and (c) the study included healthy adolescents or young adults (12-30 years).

#### **RESULTS:**

Sixty studies were included which investigated the effects of acute (n=38) and chronic (n=22) physical activity interventions on neurocognitive functions and academic performance in adolescents and young adults. Results showed that acute interventions had a moderately sized effect on attention (Hedges  $g=0.34$ ) and inhibition ( $g=0.33$ ). In a subsequent meta-regression, shorter duration of intervention was significantly associated with greater improvements in attention ( $\beta=-0.02$ ) and cognitive flexibility ( $\beta=-0.04$ ), whereas age, percentage of boys, and intensity of the exercise were not significantly related to the outcomes. Chronic interventions had a small sized effect on cognitive flexibility ( $g=0.24$ ) and language skills ( $g=0.26$ ), a moderately sized effect on processing speed ( $g=0.30$ ) and attention ( $g=0.44$ ), and a large sized effect on working memory ( $g=0.61$ ). In a meta-regression, higher percentage of boys was significantly associated with greater improvements in working memory ( $\beta=0.02$ ), whereas age, duration, frequency, and dose of intervention were not significantly related to the outcomes.

#### **CONCLUSION:**

Acute physical activity interventions might be a promising way to improve attention and inhibition and chronic physical activity interventions to improve several aspects of neurocognitive functioning and academic performance in adolescents and young adults.

### **CARDIOVASCULAR FITNESS, PHYSICAL ACTIVITY AND EXECUTIVE FUNCTIONING IN PRIMARY SCHOOL-AGED CHILDREN; A CLUSTER RANDOMIZED CONTROLLED TRIAL**

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**Objective** The current decline in physical fitness and the increased sedentary lifestyle among children, underlines the need of studies investigating the effects of physical activity. We performed a clustered-randomized controlled trial to investigate the relationship between cardiovascular fitness and executive functioning and the effects of a school-based aerobic and a cognitively demanding exercise intervention on executive functions in primary school-aged children (n = 856).

**Methods** The exercise interventions were provided four times per week for 14 weeks of primary school physical education and compared with the regular physical education program. Cardiovascular fitness was assessed with the 20m Shuttle Run Test. A set of well-defined neurocognitive functioning measures tapping into the core domains of executive function (i.e. working memory, motor inhibition and



interference control) and two lower-level neurocognitive functions (information processing and attention) was used. Neurocognitive measures were subjected to principal component analysis. Mixed model analyses tested the differences between the groups.

Results Results showed that children with higher cardiovascular fitness better performed on the executive function components Information Processing & Control and Visuospatial Working Memory. All measures contained in these components (information processing measures, motor inhibition and visuospatial working memory) contributed to the observed relations. No relationship was found between cardiovascular fitness and the other components: Verbal Working Memory, Attention Accuracy, Attention Efficiency and Interference Control. No differences were found between the exercise interventions and the control group for any of the executive functioning measures. Independently of group, the dose of moderate to vigorous physical activity (MVPA) was positively related to improved verbal working memory and attention abilities and during the intervention period. These findings suggest that exposure to higher levels of MVPA are beneficial for specific aspects of executive functioning in children.

Conclusions The present study suggests that there is a relationship between cardiovascular fitness and a specific set of executive functions and lower-level neurocognitive functions. However, our 14-week physical exercise interventions involving aerobic activity or cognitively demanding exercise did not stimulate the development of executive functioning in children. The results concerning MVPA indicate that the exposure to MVPA is a crucial aspect of the relationship between physical activity and executive functioning. These findings highlight the importance of cardiovascular fitness and physical activity for the overall health of school-aged children.

## OP-SP01 GSSI Nutrition Award Presentations

### INGESTION OF FREE AMINO ACIDS AS OPPOSED TO INTACT PROTEIN INCREASES AMINO ACID ABSORPTION BUT DOES NOT FURTHER AUGMENT POSTPRANDIAL MUSCLE PROTEIN SYNTHESIS RATES

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#### INTRODUCTION:

Protein ingestion facilitates the skeletal muscle adaptive response to exercise training. The rate of protein digestion and amino acid absorption determines the postprandial rise in circulating amino acids and, as such, modulates postprandial muscle protein synthesis rates. This study compares protein digestion and amino acid absorption kinetics and the subsequent muscle protein synthetic response following ingestion of intact protein versus an equivalent amount of free, crystalline amino acids.

#### METHODS:

Twenty-four healthy, young subjects (age:  $22 \pm 3$  y, BMI:  $23 \pm 2$  kg/m<sup>2</sup>, sex: 12M/12F) ingested 30 g intrinsically L-[1-13C]-phenylalanine and L-[1-13C]-leucine labeled milk protein (n=12) or an equivalent amount of free amino acids (n=12). In addition, subjects received primed, continuous intravenous L-[ring-2H5]-phenylalanine, L-[ring-3,5-2H2]-tyrosine, and L-[1-13C]-leucine infusions. Blood samples and muscle biopsies were obtained frequently to assess protein digestion and amino acid absorption kinetics and subsequent muscle protein synthesis rates over a 6 hour postprandial period. An unpaired t-test was used to compare overall exogenous phenylalanine release in plasma. For other parameters repeated measures ANOVA were applied to determine differences between groups over time (time as within, and group as between-subjects factor), with Bonferroni corrected post-hoc testing where appropriate. Data are expressed as mean $\pm$ SD.

#### RESULTS:

Postprandial plasma amino acid concentrations and exogenous phenylalanine appearance rates increased after ingestion of free amino acids and intact protein (both  $P < 0.001$ ), with a greater increase following ingestion of free amino acids when compared to intact protein (time\*group interaction  $P < 0.001$ ). Exogenous phenylalanine release in plasma, assessed over the 6 hour postprandial period, was greater in the free amino acid ( $76 \pm 9\%$ ) compared with the protein group ( $59 \pm 10\%$ ;  $P < 0.001$ ). Ingestion of free amino acids and intact protein strongly increased muscle protein synthesis rates based upon L-[ring-2H5]-phenylalanine (time effect,  $P < 0.001$ ), with no differences between groups (from  $0.037 \pm 0.015$  to  $0.053 \pm 0.014\%/h$  and from  $0.039 \pm 0.016$  to  $0.051 \pm 0.010\%/h$ , respectively; time\*group interaction,  $P = 0.629$ ).

#### CONCLUSION:

Ingestion of free amino acids as opposed to intact protein is followed by more rapid amino acid absorption and greater postprandial plasma amino acid availability, but this does not further augment postprandial muscle protein synthesis rates in vivo in young adults.

### EFFECTIVENESS OF COMBINED GALACTOSE-GLUCOSE INGESTION AS COMPARED TO GALACTOSE OR GLUCOSE ONLY ON POST-EXERCISE MUSCLE GLYCOGEN REPLETION

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#### INTRODUCTION:

Prolonged strenuous endurance exercise relies heavily on carbohydrates stored as glycogen in muscle and liver. Because depletion of glycogen stores has been linked with fatigue during such exercise, it is important to replenish glycogen stores in the post-exercise period. It has been suggested that combining different sugar types that preferentially target liver (e.g., fructose) or muscle (e.g., glucose) glycogen would result in optimal replenishment of total body glycogen stores. Galactose has been shown to expedite repletion of liver glycogen when combined with glucose, although effects on post-exercise muscle glycogen have not been investigated. The aim of this study was to assess the effectiveness of intake of galactose in combination with glucose as compared to galactose or glucose only on post-exercise muscle glycogen repletion.

#### METHODS:

9 recreational cyclists took part in this double-blinded randomised study (7 men, 2 women; age:  $26 \pm 8$  years;  $VO_{2peak}$ :  $51.1 \pm 8.7$  ml/kg/min;  $W_{max}$ :  $4.7 \pm 1.0$  W/kg). Each participant completed 3 experimental trials consisting of an exhaustive, glycogen lowering cycle exercise bout followed by a 4-h recovery. During recovery carbohydrate drinks were provided at a rate of  $1.2$  g/kg/h in different compositions: glucose only (GLU), galactose-glucose (GAL+GLU; 1:2 ratio) and galactose only (GAL). Muscle glycogen concentration was determined from skeletal muscle biopsies of the vastus lateralis obtained immediately after the exercise bout and following 4-h of recovery. Venous blood samples obtained during post-exercise recovery were analysed for blood metabolites.

**RESULTS:**

Replenishment of muscle glycogen was superior with GLU (+155±22 mmol/kg dry mass (DM)) relative to GAL+GLU (+97±82 mmol/kg DM; P=0.010) and GAL (+118±66 mmol/kg DM; P=0.024), but was not significantly different between GAL and GAL+GLU (P=0.426). Plasma glucose and insulin concentrations were markedly higher in GLU (6.2±1.2 mmol/L, P<0.001 and 64.5±31.2 µIU/mL, P=0.002; respectively) and GAL+GLU (6.1±1.2 mmol/L, P<0.001 and 38.1±14.3 µIU/mL, P<0.001; respectively) as compared to GAL (5.1±0.4 mmol/L and 11.8±3.0 µIU/mL). Plasma galactose concentration was higher in GAL (3.7±0.9 mmol/L) as compared to GLU and GAL+GLU (0.2±0.1 mmol/L and 0.3±0.1 mmol/L, respectively; both P<0.001), with no significant difference between GAL+GLU and GLU (P=0.272).

**CONCLUSION:**

Superior muscle glycogen synthesis was observed with GLU, which suggests GAL+GLU may not be optimal for the short-term post-exercise replenishment of total body (i.e., liver and muscle) glycogen stores. Interestingly, GAL was equally effective as GAL+GLU despite absence of increased plasma glucose or insulin concentrations which are thought to be crucial for muscle glycogen synthesis. Whether galactose can be directly utilized by skeletal muscle and/or requires conversion to glucose in the liver before being incorporated into muscle glycogen requires further investigation.

Funding source: Dairy Management Inc., USA.

## **THE EFFECT OF MANIPULATING HYDRATION STATUS DURING CYCLING IN THE HEAT ON ACUTE KIDNEY INJURY BIOMARKERS**

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**INTRODUCTION:**

The incidence of acute kidney injury (AKI) following prolonged endurance events has been reported to be 30-85%, and hypohydration may contribute to this, but well-controlled laboratory studies investigating this are lacking. Therefore, the present study aimed to investigate the effect of manipulating hydration status during cycling in the heat on AKI biomarkers.

**METHODS:**

After familiarisation, ten healthy males (age: 22 ± 4 y; VO<sub>2</sub>max: 55 ± 9 mL/kg/min) completed two trials in a randomised counterbalanced order, consisting of intermittent cycling in the heat (~35°C) at ~50% W<sub>max</sub>. Subjects consumed either minimal water (hypohydrated trial; HYP) or water to replace body mass losses (euhydrated trial; EU). Water provided was ~37°C. Subjects either cycled for 2 h or until sweat losses reached 3% body mass, whichever came first. To determine changes in plasma volume, serum osmolality and serum creatinine, blood samples were taken pre-exercise (baseline), 30 min post-exercise and 24 h post-baseline (24 h). To determine changes in urine osmolality, urinary neutrophil gelatinase-associated lipocalin (uNGAL) and urinary kidney injury molecule-1 (uKIM-1) (biomarkers of AKI), urine samples were also collected at these timepoints. Baseline and 24 h samples were collected after an overnight (>10 h) fast. From 30 min post-exercise to 24 h, subjects recorded their food and fluid intake using a weighed diet diary.

**RESULTS:**

At 30 min post-exercise, serum osmolality (HYP: 296 ± 4 mOsm/kg; EU: 283 ± 4 mOsm/kg), urine osmolality (HYP: 967 ± 116 mOsm/kg; EU: 552 ± 418 mOsm/kg), body mass loss (HYP: -2.9 ± 0.5 %; EU: -0.4 ± 0.2 %) and plasma volume loss (HYP: -5.4 ± 4.0 %; EU: -0.7 ± 2.6 %) were greater in HYP (P<0.025). Urine osmolality increased from baseline at 30 min post-exercise in HYP (P<0.001) and at 24 h in both trials (P<0.034). In both trials, body mass was lower at 24 h than baseline (P<0.023). At 30 min post-exercise, there was a trend for greater uKIM-1 (HYP: 4.4 ± 5.0 ng/ml; EU: 0.5 ± 1.9 ng/ml; P=0.068) and greater osmolality-corrected uKIM-1 in HYP (HYP: 3.9 ± 2.4 ng/mOsm; EU: 2.1 ± 2.0 ng/mOsm; P=0.076). There was no trial by time interaction (P>0.242) for uNGAL or osmolality-corrected uNGAL.

**CONCLUSION:**

These results suggest that hypohydration exacerbates the kidney injury caused by cycling in the heat. The differential responses of uNGAL and uKIM-1 suggests that hypohydration may have exacerbated injury to the proximal tubule. In addition, regardless of hydration status at the end of exercise, ad libitum food and fluid intake were insufficient to prevent mild hypohydration 24 h post-baseline, which may have implications for subsequent exercise and risk of AKI.

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# Pre-recorded CP-poster presentations

## CP-AP01 Relative age and talent identification

### THE RELATIVE AGE EFFECT IN MALE AND FEMALE ENGLISH YOUTH RUGBY UNION

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The relative age effect (RAE) is a phenomenon that represents how young who are athletes born early in the selection year are often overrepresented within youth sport settings. The contact nature of rugby union may further magnify the physiological advantages of those athletes who are chronologically older. Thus, the purpose of this study was to examine the birth quarter (BQ) distribution of English age-grade rugby union annual age-categories. Male (n=228,206) and female (n=23,563) participants were recruited from the English age-grade pathway and allocated into their 12-month annual age-category (under-7 to under-18). Data was analysed using a chi-square goodness-of-fit test to compare the observed and expected distributions. Significant differences were revealed in all male ( $p < 0.001$ ) and nine out of twelve female ( $p < 0.05$ ) annual-age categories. Further analysis revealed, although no constituent year effect was apparent, there was a within-2-year effect in the female 24-month (under-13 and under-15) age groups. Interestingly, there was an inverse within-3-year effect and constituent year effect within the female 36-month (under-18) age group. The key findings indicate there is a deep-rooted RAE within English age-grade rugby union (total combined BQ1 28% vs. BQ4 22.8%). Since the purpose of age grouping is designed to mediate fairness across coaching and competition in youth sport, the findings of a pronounced RAE in this current study suggest this strategy may not match these intended outcomes.

### IS MUSCLE TYPOLOGY IN YOUNG TALENTED TRACK AND FIELD ATHLETES A PREDICTOR FOR ADULT SUCCESS?

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#### INTRODUCTION:

It has been established that elite long distance runners have a high proportion of type I muscle fibers, whereas elite sprinters show a high proportion of type II muscle fibers [1]. Since muscle typology is largely genetically determined, young track and field athletes could become more successful when practicing a discipline that suits their muscle typology. However, longitudinal studies on muscle typology and athletic performances in young athletes are lacking, probably due to the invasive nature of muscle biopsies. Therefore, we non-invasively estimated muscle typology by proton magnetic resonance spectroscopy (1H-MRS) in young talented athletes and we tracked their performances for the subsequent 10 years.

#### METHODS:

1H-MRS was used to quantify carnosine content in the gastrocnemius medialis of 61 elite track and field athletes (IAAF score  $>1050$  [2]) and 38 young athletes (age:  $15.41 \pm 1.54y$ , 15 males and 23 females) on a 3-T whole body MRI scanner (Siemens Trio) to estimate muscle typology [3]. Young athletes were included based on the criteria that they were selected in the topsportschool and were at least 12y for girls and 14y for boys, because absolute carnosine changes during puberty [4]. From the elite athletes' muscle typology, reference ranges were formed for: 100/200m, 400m, 800m, 1500m, 3000/5000m, 10000m, marathon, long jump and decathlon/heptathlon. Young athletes were classified as matching or mismatching their discipline's reference range. Their performances were followed-up for 10 years by tracking standardized IAAF scores. A likelihood ratio chi square test was performed to analyse associations between the qualitative variables match/mismatch and  $>1050/<1050$  IAAF points. An independent sample t-test was performed to assess differences in best IAAF scores between matches and mismatches. Statistical significance was set at  $p < 0.05$ . All data are expressed as mean  $\pm$  SD.

#### RESULTS:

32 athletes were identified as matches and 6 athletes as mismatches. 12 matches (37.50%) and 0 mismatches (0.00%) attained an IAAF score  $>1050$ . Having a matching muscle typology was associated with attaining an IAAF score  $>1050$  (likelihood ratio: 5.06,  $p = 0.025$ ). However, IAAF scores were not higher in matches than in mismatches ( $997.19 \pm 101.28$  vs.  $938.67 \pm 79.09$ , respectively,  $p = 0.190$ ), presumably due to the low number of mismatches.

#### CONCLUSION:

The association between having a matching muscle typology and an IAAF score  $>1050$  suggests that young athletes could have a higher chance of becoming successful when their muscle typology matches the discipline they are practicing.

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### AGE-SENSITIVE PROGRESSION OF THE RELATIVE AGE EFFECT IN ELITE YOUTH FOOTBALL

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#### INTRODUCTION:

The Relative Age Effect (RAE) has been widely described for a multitude of sports, including football (Helsen, Winckel & Williams, 2005). Whereas in some sports RAE diminishes or even shows a reverse effect during age progression (Cobley et al., 2017), previous research identified a consistent RAE across age-groups in elite level football (Simmons & Paull, 2001; Helsen et al., 2012). In this research we present the most recent analysis regarding prevalence and magnitude of RAE across age-groups within a cohort of youth elite football players.

#### METHODS:

A total number of 958 football players aged 11 to 18 years representing certified academies of two professional clubs of German Bundesliga (n=495) and 2. Bundesliga (n=463) in seasons 2014 to 2019 served as data pool. Birth dates were listed and RAE was calculated using the Chi-Square test and Cramer's V estimated the effect sizes, calculating the magnitude of relative quartile discrepancies according to age-groups.

## RESULTS:

RAE prevailed consistently across all age-groups with a medium effect size. Cramer's V varied between 0.198 and 0.276.

## CONCLUSION:

The findings confirm earlier results of consistent prevalence of RAE during age progression. The magnitude of relative quartile discrepancy peaked at the transition from age-group U12 to U13 which may be reasoned by the extension in field size and number of players on the field due to changing competition regulations in the respective age-group. It must be concluded that even after two decades of scientific analysis RAE still negatively affects talent management in elite youth football by missing out potential talent in the cohort of late bloomers.

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### CONSISTENCY IN AGE-GROUP SWIMMING: IMPACT OF TALENT PROMOTION PROGRAMMES?

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## INTRODUCTION:

Research reveals only one of three careers to be consistent in age-group swimmers (Staub et. al, 2019). The process of long-term athlete development can be supported by structured talent promotion programmes. For example, in the former German Democratic Republic a centralised system of secondary-level sports schools was established to promote successful dual careers. In what became a model of "Verbundsysteme" today, similar programmes have not yet been implemented all over Germany (Borggreffe & Cachay, 2012). Such promoting programmes identify and select talents; a process that may be susceptible to errors (Baker et. al, 2017).

This research addresses two historically grown talent promotion programmes in age-group swimmers, born and raised in different cultural sporting environments; in this context, an impact on consistency is hypothesized.

## METHODS:

Consistency was examined in German top-100 age-group rankings (2004-2013) including three gendered cohorts (born 1995-1993; n=3.630) for the age-groups 11-18. Swimmers were assigned to two groups, referring to different talent promotion programmes, i.e., either clubs of former Eastern (n=122) or Western German (n=809) states. Ratios describe the distribution of swimmers in the different cohorts, Mann-Whitney-U test calculated median trends.

## RESULTS:

For female swimmers, ratios revealed a 2.3 in favour of Western German clubs at age 11, diminishing to a 6.7 at age 18. For males, ratios revealed a 2.2 in favour of Western German clubs at age 11, developing towards a 4.1 at age 18. Out of all cohort swimmers, 19 managed to be selected to a national squad; herein only 1 of 8 (ratio 8.0) female and 4 of 10 (ratio 1.5) male swimmers came from Eastern German clubs. Median trends support differences in Eastern vs. Western talent promotion programmes (male  $Z = -15,866$ ,  $p = .000$ ; female  $Z = -23,514$ ,  $p = .000$ ).

## CONCLUSION:

Our findings indicate a more selective talent promotion programme in former Eastern German clubs, diminishing throughout the process of long-term athlete development in which female swimmers are less consistent. Future additional research may support an (ideological) discussion, whether talent promoting programmes despite an error susceptibility justify extensive selection processes in favour of 'limited' but specified talent development; or, in contrast, whether less selective talent promotion programmes with then less specified talent development rather benefit the elite level (e.g. national squad)?

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### AN INVESTIGATION INTO MATURATION AS A CONTRIBUTING FACTOR IN THE UPPER BODY STRENGTH OF YOUTH RUGBY PLAYERS

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## INTRODUCTION:

Rugby is an intermittent contact sport, in which a selection bias exists towards early maturation (Howard et al., 2016). This emphasis on physical abilities is misplaced as late maturers often catch up and sometimes overtake early maturers with regards to physical ability (Till et al., 2014).

The current study is investigating maturation status (YPHV) as a factor when considering upper body strength in youth rugby players, in comparison to BMI.

## METHODS:

30 participants (chronological age 14.4yrs +/- 1.1yrs, height 170.8cm +/- 9.8cm, weight 61kg +/- 14.5kg) participated in the study. YPHV, BMI & upper body strength were identified. Results were given in relative and absolute terms. Participants were further categorised into maturation status groups; pre (YPHV <0.5), circa (YPHV +/-0.5), early post (YPHV 0.5 - 1.5) & late post (YPHV >1.5).

Relationships were tested using a Spearman correlation. Significance between groups was tested through the use of multiple Mann-Whitney U tests with post-hoc Bonferroni adjustments.

### RESULTS:

Maturation status groups had a stronger relationship to absolute bench press ( $r=.81$ ,  $p<0.001$ ) than YPHV ( $r=.80$ ,  $p<0.001$ ) and BMI ( $r=0.59$ ,  $p<0.001$ ).

There was significance in absolute bench press between pre & early post ( $p<0.01$ ) and circa & early post ( $<0.01$ ). There was a significance in relative bench press between pre & late post ( $p<0.05$ ) & circa & late post ( $<0.05$ ).

### CONCLUSION:

This is in line with previous findings suggesting strength gains are driven by maturation (Till et al., 2014). With strength gains peaking after peak height velocity has been reached (Philippaerts et al., 2006). The findings suggest that absolute bench press may increase within the year following PHV, while relative bench press will not significantly increase until after the first year.

A practical recommendation derived from this study would be to consider maturation when considering a youth rugby players potential for upper body strength.

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## LEVEL OF REACTIVE AGILITY AND PERIPHERAL PERCEPTION IN TALENTED YOUNG ATHLETES INVOLVED IN TEAM SPORTS

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### INTRODUCTION:

Team games are characterized by dynamic and fast-changing actions. During the game, players often change direction as a reaction to external stimuli received from the playing court, which is defined as reactive agility [1]. Visual functions play a key role in players' performance, i.e. the ability of peripheral and deep vision to affect the speed and accuracy of motor reactions to visual stimuli. The aim of the study was to evaluate the level of peripheral perception and reactive agility in talented young athletes involved in selected team sports. Moreover, the relationship between visual function and reactive agility parameters was determined.

### METHODS:

The study group was 65 boys and 97 girls aged 13 to 15 years from Voivodeship Teams in the Lower Silesia region in Poland who played basketball, volleyball, and handball. The "five-time shuttle run to gates" test was used to evaluate the level of reactive agility [2]. The best total times of the shuttle run test as well as the best time of 4,5 m linear sprint were assessed. Additionally, the peripheral perception (PP) test from the Vienna Test System was used for evaluation of visual function. The results of the PP analysis included: overall field of vision, median reaction time from left/right stimulus, and tracking deviation.

### RESULTS:

The age of study participants had the most significant effect on PP test variables (overall field vision,  $p<0.001$ ; tracking deviation,  $p<0.01$ ; reaction time,  $p<0.001$ ). Moreover, gender significantly affected the reaction time scores ( $p<0.05$ ). The sport discipline differentiated only the players' tracking deviation ( $p<0.01$ ). Furthermore, the level of reactive agility was determined by the gender ( $p<0.001$ ). Additionally, few relationships between reactive agility and the PP variables were observed. The observations were particularly concerned with the relationships between reaction times from the PP test and results obtained from the "five-time shuttle run to gates" test.

### CONCLUSION:

Visual functions differed with the age of the young athletes, even when the laboratory task was not connected with their sporting environment. Therefore, the PP test may be used as criteria to define the visual function status in subsequent stages of the recruitment and selection processes in team sports. Moreover, peripheral perception partly determined the athletes' reactive agility.

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## THE RELATIVE AGE EFFECT IN POLISH HANDBALL PLAYERS: A STUDY ON THE WHOLE POPULATION.

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### INTRODUCTION:

The requirements of youth sports lead to the age-banding of players into training groups and teams, in which sports managers age-band players to a training group relative to cut-off date points. Handball is characterized by full-body contact, dynamic actions, and different anthropometric profiles based on the players' physique (e.g. pivot) (Bjorndal, et al., 2018). Additionally, bi-annual (2-year) age categories in youth competition lead to higher physical disparities between players. Consequently, the relative age effect (RAE) phenomenon was observed in handball at all levels (Wrang et al., 2018). However, there is a lack of population-related studies indicating the overrepresentation of early-born participants at particular stages of the talent identification process. Therefore, the aim of this study was to explore the RAE in youth, amateur and professional male and female Polish handball players ( $n=16547$ ).

### METHODS:

The study includes data of all players participating in the 2017/2018 competition licensed by the Polish Handball Federation (PHF). Data on the date of birth, body mass, body height and player position on the court were obtained for female ( $n=6485$ ; aged 7-43) and male ( $n=10062$  aged 8-60) handball players from PHF. Data on the differences in the quarterly distribution of birth dates in the Polish population (PP) were obtained from the Central Statistical Office. These data corresponded to the birth dates of the players who participated in the OHT (1957-2010). The chi-square test ( $\chi^2$ ) was used to determine the differences between the observed and expected frequencies of the

date of birth quartile. The effect size was defined by calculating Cramér's  $V$  ( $V$ ). One-way analysis of variance (ANOVA) was used to determine the quarterly differences in anthropometric characteristics by players position on the court.

#### RESULTS:

The RAE was observed in all groups of male handball players (youth;  $V=0.08$ ,  $p<.0001$ , amateur;  $V=0.09$ ,  $p<.0001$ , professional;  $V=0.08$ ,  $p<.001$ ). In the female sample, significant uneven birth date distributions were shown only for youth ( $V=0.06$ ,  $p<.0001$ ). In detail analysis for youth overrepresentation of early-mate players was observed for all male categories (U12, U14, U16, U18, all  $p<.001$ ) and only in a group of U12 girls. The anthropometric data revealed a significantly lower body height for wings compared to other player's positions on the court in all-male age categories.

#### CONCLUSION:

The results showed the sexual differences in the existence of the RAE phenomenon in full-body contact ball sport which is a handball. Different maturity status between boys and girls at the age of first selections for handball youth teams (11-12 years old), may explain less discrimination to later-born players compare to boys at the same age. Therefore, RAE in womens handball at the early categories seems has less impact on the process of talent identification process..

## CP-AP03 Training and testing: Team sports

### THE PHYSIOLOGICAL PROFILE OF AN ENGLISH PREMIERSHIP RUGBY UNION ACADEMY: IMPLICATIONS FOR LONG-TERM ATHLETE DEVELOPMENT

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#### INTRODUCTION:

Practitioners working in rugby union (RU) at youth level need to consider the physiological characteristics that facilitate optimal long-term athlete development. Thus, the purpose of this study was to explore the anthropometric measures, physical performance, and relative age of RU academy players based age group and playing position.

#### METHODS:

Seventy-eight Premiership RU academy players participated in this study. Ten physiological parameters were collected at the end of the pre-season period. Players were separated by age group and playing position (forwards U16=12, U18=17, U21=4; backs U16=16, U18=25, U21=4). Parametric (one-way ANOVA) and non-parametric (Kruskal-Wallis) analysis was conducted on normal and non-normal distributed data, respectively. Post-hoc analysis was subsequently performed to examine the effect size and statistical significance between groups using Dunn's test with Bonferroni correction and TukeyHSD, respectively. The combined relative age distribution of forwards and backs was also compared against national norms using a chi-square, with odds ratios and 95% confidence intervals calculated to compare the observed distributions.

#### RESULTS:

Results demonstrated that older forwards had significantly greater ( $P<0.05$ ) body weight (U16 vs. U21:  $88.9\pm 10.4$  vs.  $111.7\pm 7.3$  kg), grip strength (U16 vs. U18 vs. U21:  $45.8\pm 7.6$  vs.  $48.6\pm 6.3$  vs.  $57.9\pm 7.5$  kg), reactive strength index (U16 vs. U21:  $1.1\pm 0.1$  vs.  $1.6\pm 0.3$  m/s), aerobic capacity (U16 vs. U18 vs. U21:  $58.8\pm 1.7$  vs.  $61.2\pm 1$  vs.  $66\pm 0.8$  mL·kg<sup>-1</sup>·min<sup>-1</sup>), and were slower on the 10 m sprint (U16 vs. U21:  $1.7\pm 0.1$  vs.  $1.9\pm 0.1$  s). In comparison, older backs had greater body weight ( $P<0.05$ ) (U16 vs. U18 vs. U21:  $71.6\pm 6.3$  vs.  $77.0\pm 9$  vs.  $89.2\pm 2$  kg), counter-movement jump (U16 vs. U21:  $35.8\pm 5.0$  vs.  $44.8\pm 3$  cm), reactive strength index (U16 vs. U21:  $1.45\pm 0.3$  vs.  $1.97\pm 0.5$  m/s), and aerobic capacity (U16 vs. U21:  $62\pm 2.2$  vs.  $69\pm 2.7$  mL·kg<sup>-1</sup>·min<sup>-1</sup>). Analysis of the relative age distribution revealed that chronologically older forwards and backs were significantly overrepresented ( $P<0.05$ ; OR=4.20 and 2.75).

#### CONCLUSION:

Key findings illustrate how anthropometric and physical performance measures differentiate based on age group and playing position. It is suggested that: (a) all players should aim to develop greater parameters of body mass and aerobic capacity with increasing age; (b) forwards should aim to develop acceleration and strength functions; and, (c) backs should aim to develop power and agility capabilities. Additionally, there appears to be a relative age effect regardless playing position, whereby chronologically older players are overrepresented throughout combined age groups and both playing positions. As such, these findings may be representative of chronologically older players, thus coaches and practitioners should be cautious when recruiting and benchmarking young players.

### PHYSICAL, PHYSIOLOGICAL, AND TECHNICAL DEMANDS OF NATIONAL NETBALL UMPIRES AT DIFFERENT COMPETITION LEVELS

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#### INTRODUCTION:

Netball is a 60 min (4 x 15 min) invasion ball game played between 2 teams of 7 players. Two umpires each control and give decisions for half of the court including the goal line, as well as giving decisions for the throw-in on their sideline. During a match, each umpire will utilise a range of movement techniques, including walking, jogging, sidestepping, changing direction and sprinting to move around their allocated sideline and goal line. To characterise optimal performance and to aid in assessment and training methodologies, it has been necessary to determine the specific requirements of umpires. The aim of the present study was to compare the physical, physiological and technical demands of national netball umpires between different levels of competition. It was hypothesised that umpires officiating in higher levels of competition would experience an increase in both high and low demand activities, but a decrease in time spent in intermediate demand activities, compared to those officiating in lower levels of competition.

#### METHODS:

Netball NZ high-performance umpires ( $n = 22$ ; 5 males, 17 females) participated in this investigation. This included, in order from highest to lowest level of competition: 9 umpires (1 male, 8 females) from the semi-professional ANZ Championships (ANZC), the premier netball league in Australia and New Zealand; 6 umpires (1 male, 5 females) from the National A Squad (NZA); and 7 umpires (3 males, 4 females)

from the National Development Squad (DEV). In total, 48 umpire match performances were observed during the 2012 season: 16 ANZC matches; 16 NZA matches; and 16 NZD matches

A separate camera (Canon LEGRIA HV40) recorded the movements for each umpire.

**RESULTS:**

Level of competition had no significant effect on physical or mean physiological demands ( $0.00 \leq F(2,45) \leq 1.25$ ;  $0.298 \leq p \leq 1.000$ ). However, ANZC umpires spent a lower proportion of time at low heart rates compared to DEV, and a greater proportion of time at high, rather than moderate, heart rates compared to NZA. Compared to lower standard umpires, ANZC spent lesser proportions of time standing but greater proportions of time walking backwards and sideways, and turning to change direction. Furthermore, ANZC umpires spent lower proportions of time jogging, but greater proportions of time sprinting compared to DEV.

Finally, ANZC umpires spent longer mean durations than DEV on the goal third sideline.

**CONCLUSION:**

The present study is the first to directly investigate the effects

of level of competition (i.e., ANZC > NZA > DEV) on physical,

physiological and technical demands on national netball

umpires. Level of competition had no effect on physical

demands or on mean physiological (e.g., heart rate) demands. Physiologically, there was no difference in overall mean

heart rate of the different levels of umpire.

The difference in demands experienced by national netball umpires between levels of competition is more technical than physical or physiological

**THE RELATIONSHIP BETWEEN GENERAL JUMPING PERFORMANCE AND VOLLEYBALL SPIKE JUMP PERFORMANCE IN ELITE FEMALE AND MALE VOLLEYBALL PLAYERS**

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**INTRODUCTION:**

In indoor volleyball, spike points are a key performance factor in competition. The volleyball spike jump is characterized by a three or four-step approach, a dynamic arm swing in the initial phase, and different movements of the dominant and non-dominant leg to transfer horizontal velocity into vertical acceleration. However, jumping performance in female and male volleyball has usually determined by general jumping performance tests (squat, countermovement and drop jumps). The scientific knowledge regarding the relationship between the general jumping performance and the requirements in the spike jump in both sexes is lacking. Consequently, the aim of this study was (1) to analyze the relationship between the countermovement jump with (CMJA) and without arm swing (CMJ), squat jump (SJ) and spike jump (SPJ) in elite female and male volleyball players, (2) to identify the sex differences in the jump heights, and (3) to determine key variables in jumping performance.

**METHODS:**

Fifteen female and fifteen male elite indoor volleyball players performed ten SPJs, CMJs, CMJAs and SJs in a randomized order. Instructions were to jump as high as possible. Data were collected via twelve Vicon MX13 cameras (250 fps), two AMTI force plates (2000 Hz), and controlled via Visual 3D software. For all jumping techniques we calculated jump height, impulse, minimal knee flexion angle and maximal knee extension angular velocity, for the CMJA and SPJ also shoulder flexion angular velocity and additional for the SPJ the approach step length and horizontal velocity of the center of mass. For statistical analysis we calculated Product Moment correlations, a repeated measures two-way ANOVA (factor jumping technique and sex) and a factor analysis (Eigenvalues>1, Varimax rotation).

**RESULTS:**

Correlations were found between SPJ height and SJ, CMJ and CMJA height in both sexes. Men jumped significantly higher as women in all analyzed jumping techniques. For female players ten out of 26 variables and for male players only three out of 26 variables correlate with SPJ height. The factor analysis determined seven factors with a cumulative variance of 88%. In the first factor we found high loads for sex (.689), jump height in the SJ (.906), CMJ (.859), CMJA (.859), SPJ (.856), maximal angular velocity in the left and right knee extension in the SJ (.906 and .866), CMJ (.863 and .862), CMJA (.859 and .818) as well as in the minimal left knee flexion angle in the SPJ (-.783). The second factor showed high loads in the left and right shoulder flexion (.848 and .874) as well as knee extension (.808 and .783) angular velocity in the SPJ.

**CONCLUSION:**

As expected male players jump higher than female players and we found a high relationship in all analyzed jumping techniques. Knee extension angular velocity determine jump height in the general jumps but not in the SPJ. The results clearly indicated that the technique in general jumps is not transferable and did not determine jumping performance in the SPJ.

**ELITE JUNIOR SOCCER GOALKEEPER PERFORMANCE - IMPACT OF LOWER LIMB POWER AND ANTHROPOMETRICS ON DEFENDING THE GOAL**

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**INTRODUCTION:**

The factors influencing the specific ball defending performance of goalkeepers are numerous (1). Both explosive power and anthropometrics are suggested to be important but their specific contributions to the unique performance of soccer goalkeepers (GKs) have yet never been examined to the best of our knowledge. Therefore, the aim of the study was to determine impact of lower limb power and anthropometrics on defending the goal.

**METHODS:**

In a cross-sectional study, 24 elite junior GKs ( $16.7 \pm 1.7$  yrs) were separated in two age groups ( $n=12$ ): younger (U16) and older than 16 (U17/19) years. Players conducted squat jumps from 110-degree knee flexion (SJ110), counter-movement jumps with arm swing (CMJA), multiple-rebound jumps (MRJ) and 10m-sprints (SP10) with split times for the 1st (SP0-5) and 2nd 5m (SP5-10). Force (F), take-off velocity (vTO) and power (P) were also calculated within the SJ110 (2). GK specific performance on ball defending during a single (Ds) and double defending (Dd) action was measured (3). Differences between age groups were tested with an unpaired t-test. Correlations between

performance and all other measurements were calculated using SPSS 23. Further, a multiple regression model was run to analyze the impact of different factors on overall performance.

**RESULTS:**

U17/19 GKs performed significantly better in all goal defending performance conditions to all corners. For all GKs, times for the bottom corners ( $1.23 \pm 0.09$ s) were faster compared to the top corners ( $1.40 \pm 0.09$ s). By setting age as a fixed variable, SJ110, vto and SP10 showed the highest bivariate correlations ( $p < 0.05$ ;  $r = 0.43-0.52$ ). Besides age, SJ110 and vTO build the best multiple regression model ( $p < 0.001$ ;  $r = 0.8$ ), indicating that  $66.2 \pm 2.2\%$  and  $60.1 \pm 3.3\%$  of the performance to the top and bottom corners could be explained, respectively. Due to its increased complexity and larger coordinative demands, none of the models were able to demonstrate a detection rate over 50% for the Dd.

**CONCLUSION:**

We demonstrated that SJ110 and vTO together with age explained 63% of the specific ball defending performance of elite junior GKs. Along with age, lower limb power subsequently increases but the results however cannot be explained solely due to physical indicators. Technical abilities also contribute substantial to the specific ball defending performance in the examined age groups. The results indicate an enhanced performance due to higher expertise in the position specific technical abilities. Practitioners should therefore focus on technical abilities and from a physical point of view on explosive power to optimize performance. Consequently, a specific diagnostic for GKs is necessary to address all demands contributing to defend the goal. Interestingly, height was not as important in our cohort for predicting goalkeeping performance as commonly believed. During the process of talent identification shorter GKs should not be ignored in youth soccer.

1 West, J. (2018)

2 Samozin et al. (2008)

3 Knoop et al. (2013)

**HIP ISOMETRIC STRENGTH IN PROFESSIONAL MALE SOCCER PLAYERS: AN OBSERVATIONAL STUDY.**

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**INTRODUCTION:**

Hip muscle strength is one of the risk factors mentioned in the literature from different sports such as soccer, ice hockey or rugby. This study was conducted to determine the hip muscles strength profile on male soccer players. The objective of the present study was to assess the early season hip muscles strength on professional male soccer players.

**METHODS:**

Twenty-two asymptomatic professional male soccer players participated in the study at early season 2019-2020. Strength tests were isometric tests (Flexion, extension, abduction, adduction, external and internal rotation) measured with a hand-held dynamometer. Both limbs were divided into kicking (preferred) and support (non-preferred) leg. After isolated strength tests, strength ratios between muscles were determined. were made between the preferred and non-preferred limbs of each participant using an independent samples t-test. An  $\alpha$  value of 0.05 was used to determine statistical significance, and effect sizes were determined using Cohen's d.

**RESULTS:**

Comparison between the preferred and non-preferred limb showed no differences between either limbs for hip flexion ( $p = 0.870$ ,  $d = 0.045$ ), extension ( $p = 0.863$ ,  $d = 0.053$ ), abduction ( $p = 0.349$ ,  $d = 0.286$ ), adduction ( $p = 0.872$ ,  $d = 0.049$ ), internal rotation ( $p = 0.577$ ,  $d = 0.169$ ) and external rotation strength ( $p = 0.572$ ,  $d = 0.169$ ). No differences were found between the preferred and non-preferred limbs for the ratios between hip flexion and extension ( $p = 0.964$ ,  $d = 0.014$ ), abduction and adduction ( $p = 0.443$ ,  $d = 0.234$ ), and internal and external rotation strength ( $p = 0.755$ ,  $d = 0.095$ ).

**CONCLUSION:**

The values of hip strength profile determined for our study can be used as reference in the clinical examination and treatment of professional soccer players. This study confirms the results of other studies that leg dominance had no effect on isolated strength or ratios between hip muscles. Further research is needed to establish normal values for hip muscle strength using hand-held dynamometer.

1) K.Thorborg et al., Scand J Med Sci 2010

2) M. Wollin et al., J S and Med in Sport 2018

3) G Leoporce et al., Sports Biomechanics 2018

4) K. Thorborg et al., Jour of Ortho SpPhysical Therapy 2018

5) N. Bourne et al., Jour of Ortho SpPhysical Therapy 2019

**HUMAN MOVEMENT VARIABILITY IN VOLLEYBALL SPIKE APPROACH BETWEEN ZONE II AND ZONE IV WITH AND WITHOUT BALL**

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**INTRODUCTION:**

The game of volleyball is characterized by short and explosive movement patterns. A volleyball match consists of different executions of specific technical skills of Volleyball such as, defense, blocking and attacking. Attack seems to be the most important ability to win in youth and senior games.

The variability of the players must be understood and perceived during the execution of the attack within the variables process (angular positioning of the joints, acceleration or contraction of the muscles) (1). In addition, in any time series, representing an output variable of the system, entropy is a measure of its uncertainty. From this perspective, volleyball spike approach movement (SM) oscillations can be evaluated, like any other time series, through entropy calculation techniques (2). The aim of this study was to identify the differences in human movement variability during SM from zone II and IV with and without the ball.

**METHODS:**

One WIMU(Realtrack systems) was located below L3 to forty eight female first division players (Mean  $\pm$ SD: Age  $17,56 \pm 3,60$ ; Height:  $1,77 \pm 0,05$ ; weight:  $67,78 \pm 7,09$ ) who performed SM in both conditions (with ball and without ball) per each area (zone IV and zone II). The players performed a standardized warm-up after which they realized in random order four sets of six SM, two of them with ball and two of



them without ball, in two sessions on different days. The human movement variability was calculated with Approximative Entropy (ApEn) and Sample Entropy (SampEn) through the modulus of acceleration.

RESULTS:

The ApEn and SampEn response variables were analysed using a Mixed linear Model, where SM with or without ball is the main variable explanatory (SMball) and, different zones as a secondary variable explanatory (SMzone). The means in SampEn were, without ball (M: zIV=0,062; zII=0,062) and with ball (M: zIV=0,089; zII=0,089), No significant differences were found in SMzone ( $p=0,6801$ ); Significant differences were found in SMball ( $p<0,001$ ). Also in ApEn the means were, without ball (M: zIV=0,144; zII=0,144) and with ball (M: zIV=0,165; zII=0,163), Significant differences were found in SMball ( $p<0,001$ ) but not in SMzone ( $p=0,9485$ ).

CONCLUSION:

Movement variability of the players performing SM is not affected if it is done on the different sides of the volleyball court (zone II and zone IV), however it is increased if the SM is performed with ball.

1. Dias G et al. (2014), 2. Stergiou N. (2016)

**PHYSIOLOGICAL DEMANDS IN SOCCER SPECIFIC SMALL-SIDED GAMES: TRAINING ANALYSIS IN MALE ELITE YOUTH SOCCER PLAYERS**

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INTRODUCTION:

Small-sided games (SSGs) are often used in team sports to improve players' physical, technical, and tactical abilities [1]. They have been proven to be a compact and time efficient training tool [2]. However, little research exists to determine the physiological demands in such training formats. Therefore, the aim of this study was to identify the activity profile during SSGs in different age groups in male youth soccer.

METHODS:

33 male elite youth soccer players from three different age groups (U15/U16/U18) participated in this study. Activity of 18 SSGs was recorded. The 4+1 (5v5) match play on two goals (40x32m field) consisted of 4 bouts of 2min with 2min recovery breaks. Activity was tracked via Local Position Measurement System. Variables included percentage of mean heart rate (%HRmean) in relation to maximum heart rate, time spent (s) in 4 different HR-zones (HRz), distance covered (m) in high intensity running (HIR) >13km/h and 6 different speed-zones (Sz), and total distance covered (m). Furthermore, rate of perceived exertion (RPE) was recorded after each training session. Differences between age groups were analysed using MANOVA. Significant results were interpreted using post-hoc-analyses. Effect sizes were calculated as partial eta-squared ( $\eta^2$ ). Statistical significance was set at  $p<0.05$  with a confidence interval of 95%.

RESULTS:

Results showed differences between age groups for distance covered in Sz1 (U15: 25.21  $\pm$ 16.69, U16: 31.47  $\pm$ 10.99, U18: 37.57  $\pm$ 19.18m,  $p=0.035$ ,  $\eta^2=0.074$ ) and Sz3 (U15: 86.50  $\pm$ 13.09, U16: 79.68  $\pm$ 13.41, U18: 78.68  $\pm$ 12.78m,  $p=0.030$ ,  $\eta^2=0.077$ ) with lower values for U15 compared to U18. On the other hand, U15 covered greater distance in Sz4 (U15: 75.67  $\pm$ 11.81, U16: 71.22  $\pm$ 10.49, U18: 68.06  $\pm$ 11.43m,  $p=0.027$ ,  $\eta^2=0.079$ ). Similarly, U15 spent less time in HRz3 (U15: 105.90  $\pm$ 68.13, U16: 128.55  $\pm$ 72.38, U18: 151.07  $\pm$ 67.95s,  $p=0.004$ ,  $\eta^2=0.117$ ), and higher amounts in HRz4 (U15: 203.51  $\pm$ 92.67, U16: 173.77  $\pm$ 91.86, U18: 138.36  $\pm$ 77.68s,  $p=0.025$ ,  $\eta^2=0.081$ ). Furthermore, U18 showed lower RPE values (U15: 8.68  $\pm$ 0.36, U16: 8.36  $\pm$ 0.64, U18: 7.81  $\pm$ 0.98s,  $p=0.000$ ,  $\eta^2=0.202$ ) compared to other age groups.

CONCLUSION:

Results showed differences in physiological and perceptual parameters between age groups in soccer specific SSGs. Findings of this study indicate lower intensities in higher age groups. Reasons could be an improved understanding of the game and therefore a more efficient style of play, or a better fitness level in older players. However, these differences should be taken into account when drafting soccer specific SSGs.

1. Dalen et al. (2019). Differences in Acceleration and High-Intensity Activities Between Small-Sided Games and Peak Periods of Official Matches in Elite Soccer Players. J Strength Cond Res.

2. Bujalance-Moreno et al. (2019). A systematic review on small-sided games in football players: Acute and chronic adaptations. J Sports Sci.

**IMPROVEMENT OF HANDBALL SAFETY THROUGH THE GOALPOST ANTI-TIP SYSTEM ACCORDING PLAYERS, COACHES AND REFEREES OPINION. 2019 LÜBECK NATIONS-CUP INTERNATIONAL HANDBALL TOURNAMENT.**

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INTRODUCTION:

Handball it is a sport practiced by millions of people all over the world. Goals are an essential equipment to practice it and the anti-tip system provides stability and prevents fall of them. It is fundamental that this element being safe to avoid accidents and to prevent injury. The sport equipments and in particular, the goalposts cause accidents and unfortunately eaths around the world. In Spain since 2000th have died 18 children (1), in Germany between 1996 and 2013 six children and eight more died in Central Europe countries (2).

The goals are usually anchor to the sports hall floor; but is not the case when sometimes are placed in different parts of the field depending on the type of training, number of groups using the field at the same time or minihandball. The handball rules require fixing the goal to the floor or wall behind it but this is not always possible.

The objective of this study is to know the opinion that different sports agents have with the use of the Tutigool goals anti-tip system, as a prevention and safety measure. This device does not require anchoring in the floor.

METHODS:

A questionnaire with 18 items Tutigool anti-tip system has been administered to the coaches, players and referees at 2019 Nations Cup International Handball Tournament held in June in Lubeck (Germany) and 120 questionnaires have been completed.

The participating were 5 teams males (born 2000/2001), 4 teams females (born 2002/2003), 9 coaches and 16 referees.

And Tutigool anti-tip goalpost system has been used to play the complete 13 matches in the tournament. It does not anchor the goal and allows the impact's absorption in case of a player's collision with the goalpost.

**RESULTS:**

78.3% of the participants in the tournament did not know the Tutigool anti-tip system. The overall satisfaction is 4.62 out of 7. Coaches gave the highest valuation with a 6. By teams the highest rating was awarded by TSV Nord Harrislee (female) with a 5.3 and the lowest rating was 3.63 for the mens Norwegian national team.

In general, using the Tutigool anti-tip system "for school and young categories" is more valued than for the "highest competitive level". Referees have given the most differentiated between those variables; it was 5.5 against 3.81 respectively.

**CONCLUSION:**

It is useful and necessary to use alternative anti-tip systems that guarantee the safety of users anywhere in the field, without having to anchor the goalposts.

Previous studies and this research have done a deep reflection to the International Handball Federation (IHF) and with the aim of improving handball safety has changed the rule 1:2 of the official handball guidelines since 1 July 2019.

**REFERENCES**

- 1) García-Tascón, Deporcam 40, 6-7, 2018
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- CONTACT: margata@upo.es

**GAME-BASED VS MULTILATERAL TRAINING APPROACH: EFFECTS OF A 12-WEEK PROGRAM ON MOTOR SKILL ACQUISITION AND PHYSICAL FITNESS DEVELOPMENT IN SOCCER SCHOOL CHILDREN**

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**INTRODUCTION:**

The importance of motor skill acquisition, physical development and health-related fitness of children has been significantly noted. (William et al, 2008). Nowadays, sport disciplines are extremely focused in young athlete development to improve performance levels and to identify future talent (Huijgen et al. 2009). This study investigates the effects of a 12-week-game-based training on motor skills acquisition compared with a traditional open-skill multilateral schedule.

**METHODS:**

40 children (two team of 20 players each) belonging to a soccer school were recruited for this study. Each team was assigned to game-based or multilateral approach training group All their parents approved the attendance at this study by signing an informed consent. Training period was 12 weeks and players were tested at baseline and after 12 weeks of training on standing long jump, shuttle dribble test, 10x5 shuttle test and Mini-Cooper test.

**RESULTS:**

Both Game-Based Group (GB) and Multilateral Approach Group (MA) improved significantly in standing long lump ( $p < 0,001$  for both groups), shuttle dribble test ( $p < 0,001$  for both groups), shuttle run test ( $p < 0,01$  for both groups) and Mini-Cooper test (GB  $p < 0,001$ ; MA  $p < 0,01$ ). At the end of the study, a significant difference was detected in shuttle run test comparing GG and MA in favour of MA on shuttle run test ( $p < 0,01$ ; +8%), while no difference was found in all other parameters.

**CONCLUSION:**

Data shows that both game-based training and a multilateral approach schedule can provide improvements in children motor skills acquisition and fitness development. However, M-AG received a greater effect on physical conditioning. Considering this, a multilateral approach does not nullify technical skills acquisition, so it might be possible to advice trainers to focus on both technical and fitness abilities to ensure a complete coordinative and physical development

**EFFECTS OF PHYSICAL FATIGUE ON VISUAL PERCEPTION IN BADMINTON: A PRELIMINARY STUDY.**

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**Introduction**

In badminton, capacity to quickly perceive relevant information is one of the most important performance determinant. However, a limited number of studies investigated the effects of fatigue on field gaze behaviours. The aim of this study was to determine the effects of physical fatigue on reaction time (RT) and gaze durations (GD) during a badminton game.

**Methods**

Two men and two women non-experienced in badminton participated in this study ( $25.7 \pm 0.5$  years). Before (pre) and after (post) a fatigue protocol, they performed one set of badminton against the same opponent. Fatigue protocol (constructed by a professional coach) consisted to run during 2 blocks of 8 minutes with different trajectories on the court. During each set, a camera video (JVC GC PX100) recorded participants and opponent behaviours. The participants were equipped with eye tracking glasses (Pupil Core Labs) to measure gaze behaviours. RT (690 observations) were measured from the field camera, and GD (2571 observations) were measured from the eye-tracking camera using pre-defined areas of interest extracted from Triolet et al. (2013): racket, shuttlecock, upper body, lower body, field and empty area. We analysed our data using linear mixed effect models with participant as random variable.

**Results**

RT was longer for post ( $245 \pm 276$  ms) than pre ( $217 \pm 113$  ms) fatigue protocol ( $p < 0.05$ ). Independent of the area, GD were longer for pre ( $140 \pm 131$  ms) than post ( $127 \pm 108$  ms) fatigue protocol ( $p < 0.005$ ).

**Discussion**

Post fatigue protocol, participants showed longer RT. To our knowledge, no study linked physical fatigue and reaction time in badminton. Moreover, participants showed shorter GD for post fatigue protocol. We found that non-experienced players had more fixations on shuttlecock and empty areas than on the opponent (racket or high body part). The proportion of fixations on shuttlecock could be explained by the level of participants. Indeed, experts tend to use tactical information to anticipate before the opponent's stroke (Triolet et al., 2013). The proportion of fixations on empty areas could be explained by the anticipation of the impact between shuttlecock and the racket of the opponent.

However, the small sample size limits the interpretations, and more participants will be enrolled in this study to better understand the effect of fatigue on the links between gaze behaviours and RT in badminton. Additionally, replicating this study with a sample of elite level badminton players could bring knowledge on the specific links between gaze behaviours and RT in experts and could be completed by attentional tasks to better understand the effects of fatigue.

References

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**POSITION-SPECIFIC CHARACTERISTICS OF RUNNING DISTANCE FOR JAPANESE JUNIOR RUGBY PLAYERS MEASURED USING GPS.**

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INTRODUCTION:

An official rugby union match is played by 15 players in each team, whereas Japanese junior (U-15) rugby match is played by 12 players in each team excluding flanker and No.8. Rules and pitch size of the Japanese junior rugby match are almost the same as an official rugby union match. Thus, it is possible that the characteristics of play in Japanese junior rugby match especially running distance are different from those in rugby union match. Running distance of each player during the match has been measured using global positioning system (GPS) in many studies. Therefore, this study aimed to investigate position-specific characteristics of running distance for Japanese junior rugby players during a match.

METHODS:

The running distance of each player from one elite Japanese junior rugby team in five 20-min half matches was recorded using GPS unit (SPI High Performance Unit, GPSports). In this study, running distances in the first half of the matches were analyzed. The running distance were presented as mean and standard deviation for each playing position. Student's t-test was used to test differences between forward players and backs players, and one-way analysis of variance (ANOVA) was used to examine differences in the variables between playing positions. Significance level was set at  $p < 0.05$ .

RESULTS:

There was no significant difference in total running distances ( $p = 0.393$ ) between the forward ( $1571 \pm 152$  m) and backs players ( $1617 \pm 231$  m) in the matches. Moreover, there was also no significant difference in running distance ( $p = 0.286$ ) between PR ( $1594 \pm 136$  m), HO ( $1542 \pm 128$  m), LO ( $1622 \pm 177$  m), SH ( $1802 \pm 273$  m), FH ( $1594 \pm 284$  m), CTB ( $1518 \pm 226$  m), WTB ( $1608 \pm 176$  m), and FB ( $1663 \pm 208$  m).

CONCLUSION:

The current results show that running distance is not differ between the forward and the backs in Japanese junior rugby. The running distance of backs players was higher than that of the forward player in previous research including study using Japanese university players [1,2]. The field where each athlete needs to cover is relatively large due to small number of players in Japanese junior rugby. In addition, the running distance per time of backs players was almost the same as the previous studies [1,2]. For this reason, a forward player is likely required to run long distance as same as the backs player in Japanese junior rugby.

REFERENCES:

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- 2) Furukawa et al., *Jpn J Coach Stud*, 2013

**EFFECTS OF PRE-COMPETITIVE PREPARATION PERIOD ON PHYSICAL, BIOCHEMICAL AND PSYCHOLOGICAL CHARACTERISTICS IN PROFESSIONAL RUGBY UNION PLAYERS.**

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INTRODUCTION:

In team sports, such as Rugby union (RU), in order to prepare for the very long period of competition, the pre-competitive preparation period (Pc2P) usually involves the development of technical and tactical qualities and those of all the physical qualities [1,2,3]. Quantifying the workload (WL) imposed by training and competition constitutes a fundamental step in understanding the dose-response relationship between stress and physiological adaptations [4]. Although certain studies have analyzed the physical and physiological changes in rugby players [1], no studies have referred to changes in WL, physical, biochemical and psychological characteristics during Pc2P in professional RU players. We hypothesized that Pc2P would be an appropriate period to develop all these parameters.

METHODS:

Nineteen professional RU players ( $27.05 \pm 3.07$  years) volunteered to participate in this study. All these players play for the same second division team playing in the French championships (Pro D2). All of the data were recorded during Pc2P which lasted 12 weeks, including 3 blocks. The 3 blocks last 3 weeks, 4 weeks and 3 weeks respectively. To evaluate the "dose of the training", we used the S-RPE method and GPS method to respectively assess the internal and external WL. To evaluate participants' biochemical adaptations and aerobic capacities, the biochemical indicators [Creatine kinase (CK), testosterone (T), cortisol (C) and IGF-1] and the Yo-Yo Intermittent recovery Test Level 1 (YYIRT1) were measured and recorded. Finally, to study the psychological adaptations, the Hooper questionnaire was used.

RESULTS:

Internal WL. For all subjects, and depending on the players' position, our results show that both S-RPE and training volume show a significant decrease ( $p < 0.01$ ) in block 3 compared to blocks 1 and 2. Our results also show that Hooper score in block 3 is significantly lower ( $p < 0.05$ ) than in block 2. No significant differences were observed between backs and forwards for S-RPE, volume and Hooper score.

External WL. Total distance (TD) in block 2 is significantly higher ( $p < 0.01$ ) than the other 2 blocks. high-speed running distance (HSD) in block 3 is significantly lower ( $p < 0.01$ ) than in blocks 1 and 2. Our results also show a significant decrease of sprint running distance (SD) ( $p < 0.05$ ) and number of impacts ( $p < 0.01$ ) in block 3 compared to block 2. According to the players position, our results show that TD in block 2, HSD and SD in 3 blocks, accelerations (Acc) in blocks 2 and 3 and number of impacts in blocks 1 and 2 of backs are significantly higher ( $p < 0.01$ ) in backs compared to forwards.

CONCLUSION:

Despite the complexity of managing this period of development of general physical properties (Pc2P), our results showed significant changes in WL, physical, biochemical and psychological characteristics during Pc2P in professional RU players.

1. Argus et al. (2010) 2. Bradley et al. (2015) 3. Zemski et al. (2018) 4. Dubois et al. (2018)

### INDIVIDUAL RESPONSE TO EXTERNAL TRAINING LOAD IN ELITE FOOTBALL PLAYERS

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#### INTRODUCTION:

Training load monitoring via the use of various internal and external measures is commonly used in elite team sports with the aim to determine and gain a greater understanding of individual training responses and assess fatigue and need for recovery [1]. The magnitude of individual responses to external load has, however, been scarcely investigated [2]. The aim of this study was to investigate the within-player effect, between-player effect, and individual response of external training load from player tracking devices on session rating of perceived exertion training load (sRPE-TL) in elite football players.

#### METHODS:

Eighteen male players from one football team participating in the Norwegian Premier league (age  $26 \pm 5$  y, height  $183 \pm 6$  cm, body mass  $80 \pm 9$  kg), took part in this study. The authors collected sRPE-TL from 21 training sessions, which were typically three days after match day. Total distance, high-speed running distance ( $>14.4$  km/h), very high-speed running distance ( $>19.8$  km/h), PlayerLoadTM, PlayerLoad2DTM, and high-intensity events (HIE  $> 1.5$ , HIE  $> 2.5$ , and HIE  $> 3.5$  m/s) were extracted from the tracking devices (OptimeEye S5, Catapult Sports). The authors modeled within-player and between-player effects of single external load variables on sRPE-TL, and multiple levels of variability, using a linear mixed model. The effect of 2 SDs of external load on sRPE-TL was evaluated with magnitude-based decisions.

#### RESULTS:

Total distance, PlayerLoadTM, Player- Load2DTM, and HIE  $> 1.5$  had most likely substantial within-player effects on sRPE-TL (100% to 106%, very large effect sizes). Moreover, the authors observed likely substantial between-player effects (12% to 19%, small to moderate effect sizes) from the majority of the external load variables and likely to very likely substantial individual responses of PlayerLoadTM, high-speed running distance, very high-speed running distance, and HIE  $> 1.5$  (19% to 30% coefficient of variation, moderate to large effect sizes). Finally, sRPE-TL showed large to very large between-session variability with all external load variables.

#### CONCLUSION:

External load variables with low-intensity thresholds had the strongest relationship with sRPE-TL. Furthermore, the between-player effect of external load and the individual response to external load advocate for monitoring sRPE-TL in addition to external load. Finally, the large between-session variability in sRPE-TL demonstrates that substantial amounts of sRPE-TL in training sessions are not explained by single external load variables.

1. Bourdon, et al. IJSP 2017; 2. McLaren, et al. Sports Med. 2018.

### ACTIVITY PROFILE OF HIGH-LEVEL ICE HOCKEY PLAYERS - POSITIONAL DIFFERENCES IN THE FREQUENCY OF OCCURRENCE OF HIGH-INTENSE ACCELERATION WITHIN SHIFTS

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#### INTRODUCTION:

Quantifying and describing the high-intensity acceleration occurring during a game enables practitioners to have a better understanding of the position-specific physical requirements and thus to design appropriate training exercises. The aim of the study was to investigate positional differences in the average frequency of occurrence of high-intense acceleration (HIA) per shift during a game as well as to look at which initial speed these accelerations were initiated from.

#### METHODS:

Match activities of 18 players were collected using a local positioning measurement system (LPM, Inmototec) during an international elite ice hockey game. The players were grouped according to their playing position in Defenseman (D), Center (C) and Winger (W), resulting in  $n = 6$  match-files for each position. A total of 295 shifts were analyzed ( $n = 108, 107$  and  $77$  for D, C and W, respectively). As suggested by Sonderegger et al. (2016), a variable acceleration threshold was chosen to identify HIA. The threshold ( $m \cdot s^{-2}$ ) was calculated as a function according to the initial speed: HIA-threshold =  $3.48 + \text{initial Speed} (-0.34)$ . Four different groups of initial speeds were created using k-means cluster analysis -  $< 6 \text{ km} \cdot \text{h}^{-1}$  "slow skating";  $6.1-12 \text{ km} \cdot \text{h}^{-1}$  "moderate skating";  $12.1-18 \text{ km} \cdot \text{h}^{-1}$  "fast skating";  $> 18.1 \text{ km} \cdot \text{h}^{-1}$  "very fast skating". The Kruskal-Wallis test with the Dunn-Bonferroni post hoc test was carried out as a measure to assess the positional differences. The level of significance was set at  $p < 0.05$ . Effect sizes were calculated using Cohen's  $d$ .

#### RESULTS:

In total, players completed 3125 accelerations from which 635 were classified as HIA. Significant positional differences were found in the average occurrence of overall HIA per shift ( $\chi^2 = 8.80, p = 0.01$ ). The post-hoc test showed that W ( $2.5 \pm 1.7$ ) performed a similar number of HIA per Shift as C ( $2.2 \pm 1.5$ ), but more HIA per Shift than D ( $1.8 \pm 1.4, ES = 0.46$ ). In addition, W ( $0.67 \pm 1.0$ ) and C ( $0.34 \pm 0.6$ ) performed significantly more HIA starting from very fast initial skating speeds compared to D ( $0.13 \pm 0.3$ ) ( $ES = 0.75$  and,  $ES = 0.44$ , respectively).

#### CONCLUSION:

Our data demonstrate significant positional differences in the average number of HIA performed per shift as well as differences in the number of HIA initiated from very fast skating speed. W exhibit a more intense skating profile, which is in line with the existing literature although different indicators were analyzed (e.g. Lignell et al., 2018).

### EFFECT OF FIFA 11+ ON H/Q RATIO IN MALE COLLEGE SOCCER PLAYERS

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#### INTRODUCTION:

It is known that injuries in soccer games often occur in the lower limbs. Typical sites of occurrence of lower limb injuries are the knee and ankle joints and the musculature of the thighs. Owing to this, FIFA Medical Assessment and Research Centre (F-MARC) has developed and recommends FIFA 11+ as a warm-up program aimed to prevent injury such as anterior cruciate ligament (ACL) injury and muscle strain (Bizzini M 2015). Many reports have shown that FIFA 11+ reduced the incidence of injuries in various parts of the lower limb. However, these studies only evaluate the rate of occurrence and it is unclear about whether FIFA 11+ is effective.

## CP-AP04 Training and testing: Strength

By the way, the H/Q ratio (calculated by dividing the hamstrings (H) peak torque (PT) by the quadriceps (Q) PT) is often used as a risk factor for ACL damage and hamstring injuries (Ayala F 2012). Also, because injury is likely to occur when the knee is closer to full extension ( $0^{\circ}$ – $40^{\circ}$ ), the H/Q ratio in this region can be used as a predictor of injury. Thus, as one of the mechanisms by which FIFA 11+ reduces the incidence, we hypothesized that the implementation of FIFA 11+ would contribute to maintaining the H/Q ratio of the lower limbs within a normal range.

### METHODS:

A total of 11 male college soccer players ( $18.9 \pm 0.9$  y,  $1.75 \pm 0.07$  m,  $68.5 \pm 7.2$  kg) participated in the study. The knee joint extension and flexion muscle strength (isokinetic concentric and eccentric strengths at 60 deg/sec, 180 deg/sec, and 240 deg/sec in the dominant leg) is measured using a dynamometer (manufactured by BIODEX). FIFA 11+ will be implemented on another day, and the same items will be measured immediately after implementation. Then calculate H/Qconv (ratio of flexion concentric PT to extension concentric PT) and H/Qfunc (ratio of flexion eccentric PT to extension concentric PT) at different angular velocities, further, H/Qfunc at the knee joint angle of 15, 30, and 45 degrees is calculated.

### RESULTS:

Before and after implementing FIFA 11+, neither H/Qconv with PT ( $0.48 \pm 0.04$  vs  $0.47 \pm 0.04$ ,  $0.56 \pm 0.09$  vs  $0.51 \pm 0.1$ ,  $0.58 \pm 0.07$  vs  $0.56 \pm 0.1$ ) nor H/Qfunc with PT ( $0.65 \pm 0.06$  vs  $0.66 \pm 0.07$ ,  $0.93 \pm 0.15$  vs  $0.88 \pm 0.19$ ,  $1.08 \pm 0.19$  vs  $1.04 \pm 0.18$ ) did not show significant difference at three angular velocities. H/Qfunc at knee joint angle of 15, 30, and 45 degrees also did not show any significant difference depending at three angular velocities (60deg/sec:  $2.16 \pm 0.51$  vs  $2.08 \pm 0.41$ ,  $1.18 \pm 0.15$  vs  $1.19 \pm 0.25$ ,  $0.73 \pm 0.11$  vs  $0.75 \pm 0.17$ , 180deg/sec:  $2.11 \pm 0.69$  vs  $2.17 \pm 0.67$ ,  $1.33 \pm 0.28$  vs  $1.37 \pm 0.35$ ,  $0.95 \pm 0.12$  vs  $0.96 \pm 0.2$ , 240deg/sec:  $2.57 \pm 0.63$  vs  $2.89 \pm 0.63$ ,  $1.61 \pm 0.27$  vs  $1.64 \pm 0.31$ ,  $1.12 \pm 0.15$  vs  $1.16 \pm 0.16$ ).

### CONCLUSION:

In male college soccer players, PT H/Qconv and H/Qfunc, and H/Qfunc at knee joint angle of 15, 30, and 45 degrees did not change before and after implementation of FIFA 11+.

## CP-AP04 Training and testing: Strength

### EXTERNAL AND INTERNAL LOADS IN ELITE BADMINTON SINGLES MATCH PLAY

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### INTRODUCTION:

Knowledge about the work load profile in specific sports is essential to improve training efficiency by developing sport-specific performance assessment tools and evidence-based training contents. The aim of this study was to establish a comprehensive performance profile of elite badminton singles match play, containing general match characteristics, external and internal loads.

### METHODS:

Nine elite badminton players (two female and seven male) performed a badminton match of two sets lasting 15 min, each. Temporal (number and duration of rally and resting phases, effective playing time [EPT], work density) and notational (number of strokes per rally or second, number of jumps) match characteristics as well as external loads (distance [TD], speed [v], acceleration [a]) were determined by video recordings and local positioning measurement system (LPS). Internal loads (oxygen uptake [VO<sub>2</sub>], respiratory exchange ratio [RER], breathing frequency [BF], heart rate [HR], blood lactate concentration [La], energy expenditure [EE]) were measured by portable gas exchange measurement (breath-by-breath), heart rate monitoring and analysis of blood samplings that have been taken pre, post and five minutes after each set.

### RESULTS:

A total of 702 rallies was analysed. Average rally and resting duration were  $6.97 \pm 0.81$  s and  $12.13 \pm 1.66$  s, respectively. EPT made up  $37 \pm 2$  % of total playing time reflecting work density of  $0.59 \pm 0.07$ . Players conducted averagely  $23 \pm 6$  jumps per match,  $6.9 \pm 0.7$  strokes per rally and  $0.94 \pm 0.03$  strokes per second and covered  $1337 \pm 62$  m per match. Velocities did not exceed  $3.84 \pm 0.37$  m·s<sup>-1</sup>, while accelerations of up to  $3.49 \pm 0.98$  m·s<sup>-2</sup> could be observed. VO<sub>2</sub>, HR, RER and BF reached mean values of  $36.2 \pm 4.5$  ml·min<sup>-1</sup>·kg<sup>-1</sup>,  $153 \pm 11$  beats·min<sup>-1</sup>,  $0.89 \pm 0.03$  and  $42 \pm 11$  breath per min, with peak values of  $59.8 \pm 7.9$  ml·min<sup>-1</sup>·kg<sup>-1</sup>,  $177 \pm 10$  bpm,  $1.06 \pm 0.04$  and  $77.42 \pm 7.23$  breath per min, respectively. Mean aerobic EE was  $1236 \pm 254$  kJ per match and  $0.59 \pm 0.08$  kJ per minute and kg body weight. La ranged from lowest 0.65 to highest 4.46 mmol·l<sup>-1</sup>.

### CONCLUSION:

Temporal and notational analyses describe a fast paced, intermittent match structure. Quick accelerations point high physical intensity and neuromuscular load. The variable physiological response of VO<sub>2</sub> and HR, together with constantly high RER and BF, high aerobic EE and low blood lactate concentrations, indicate that energetic costs in badminton are predominantly allocated by anaerobic alactic but not lactic capacity, while well-developed aerobic capacity is necessary for fast recovery between the rallies. Therefore, designing training contents and performance assessment in a manner that focus on development of quick acceleration and deceleration as well as on high aerobic and anaerobic alactic but less on lactic endurance capacity, is recommended.

### CHANGES IN PRESEASON TRAINING LOAD, FATIGUE AND PAIN IN DIII LACROSSE PLAYERS

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### INTRODUCTION:

Recently there has been a large focus on the impact of training load (TL) on injury in athletes (1, 2). However, there is a lack of research examining the relationship between TL and performance in collegiate sports, particularly in high load phases of the season (e.g., pre-season). This study monitored changes in TL, fatigue and pain in DIII College lacrosse players during pre-season and examined the relationship between variables.

### METHODS:

Thirty-three male varsity lacrosse athletes were recruited (age-  $19.9 \pm 1.3$  yrs, height-  $181.1 \pm 5.6$  cm, weight-  $82.8 \pm 7.4$  kg). Drop Jump (DJ) performance was measured immediately prior to (pre-test), seven days following (mid-test) and immediately following the beginning of

pre-season training (post-test). Players rated their perceived level of exertion (sRPE) and pain after all preseason training sessions. Reactive Strength Index (RSI) was calculated from DJ data and changes in RSI ( $\Delta$ RSI) were used to measure fatigue. TL was calculated as the product of sRPE and session duration. Due to missing data, a paired samples t-test with Bonferroni's correction was used to detect significant changes in RSI between the three testing time points. Two repeated measures ANOVAs were used to examine the change in TL and pain. Pearson's correlation was used to examine the relationship between TL and  $\Delta$ RSI. Spearman's correlation was used to test relationship between TL and pain.

#### RESULTS:

Results showed no difference in TL between pre- and mid-test time points ( $p = .35$ ,  $d = .29$ ). There was a decrease in TL between mid- and post-test ( $p < .01$ ). There was a significant decrease in RSI from pre- to mid-test ( $p < .01$ ,  $d = -.97$ ) but no change from mid- to post-test ( $p = .45$ ,  $d = .21$ ). Perceived pain increased significantly from pre- to mid-test ( $p = .01$ ,  $d = -.57$ ) and significantly decreased from mid- to post-test ( $p = .05$ ,  $d = .46$ ). Analysis showed no correlation between TL and  $\Delta$ RSI or pain and  $\Delta$ RSI throughout the study ( $p > .05$ ). A strong correlation was observed between TL and pain from pre- to mid-test ( $r = .56$ ,  $p < .01$ ). A moderate significant correlation was seen between TL and pain from mid- to post-test, ( $r = .41$ ,  $p < .05$ ).

#### CONCLUSION:

We observed significant changes in DJ performance from pre- to mid-test which never recovered to baseline despite reductions in perceived TL and pain. Perceived TL and pain were not correlated to  $\Delta$ RSI in DIII College lacrosse players. DJ RSI is useful to monitor neuromuscular fatigue in athletes during pre-season (3, 4). sRPE and CR-10 scales may not be sufficiently sensitive to detect changes in RSI. Using perceptions of training load and pain to guide training practices in preparation for competition is questionable, particularly in condensed training periods.

1. Soligard et al. (2016) 2. Drew & Finch (2016) 3. Dubois et al. (2018) 4. Gathercole et al. (2015)

### RISE OF SPORT AND EXERCISE SCIENCE IN PAKISTAN: A CROSS-SECTIONAL STUDY TO ASSESS AND COMPARE CARDIO-RESPIRATORY FITNESS PARAMETERS AMONG BODYBUILDERS AND NON-BODYBUILDERS.

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#### INTRODUCTION:

Physical fitness and athletic performance can be assessed through parameters like volume oxygen maximum (VO<sub>2</sub>max), blood lactate levels, respiratory exchange ratio (RER), maximum heart rate (HR) and body fat %. Sedentary or physically active lifestyles can modify these parameters. The study determines and compares these fitness indicators in active bodybuilders and inactive non-bodybuilders

#### METHODS:

A cross-sectional comparative pilot study was carried at the sport and exercise Physiology Lab at Post-Graduate Medical Institute Lahore, Pakistan. After Ethical board approval, twelve (12) healthy male subjects between age range of 20-30 years were recruited through stratified random sampling. Subjects with history of smoking or drug abuse were excluded. Participants were divided into two (2) equal groups; Group I (n=6): regularly active bodybuilders and Group II (n=6): inactive non-bodybuilders, as defined by ACSM's guidelines for exercise. Exercise pre-participation health screening was done via Physical Activity Readiness Questionnaire (PAR-Q+). Anthropometric measurements were recorded including age, weight, height and body fat percentage. Bruce protocol was used in which the participant underwent a graded exercise test till exhaustion on a treadmill. HR was recorded continuously using Bluetooth Polar belt. Cortex Metalyzer 3B-R3 was used for breath to breath gas analysis of various cardio-respiratory fitness parameters like VO<sub>2</sub>, VCO<sub>2</sub>, RER. Post exercise blood lactate levels were recorded from fingertip using Nova Biomedical Lactate Plus meter. Results were printed as 12-panel plots and quantitative values. SPSSv20 used for analysis.

#### RESULTS:

All 16 participants were in healthy weight BMI range. Values are expressed as mean $\pm$ SD in active bodybuilders vs inactive non-bodybuilders: age 23.6 $\pm$ 1.3 vs 24.2 $\pm$ 2.3 years; Body fat % 16.2 $\pm$ 1.4% vs 20.0 $\pm$ 1.6%; VO<sub>2</sub>peak 40.2  $\pm$ 2.8 vs 26.8 $\pm$ 3.3 ml/kg/min ( $p < 0.05$ ); HRmax 185 $\pm$ 3 vs 198 $\pm$ 7 beats/min ( $p < 0.05$ ); Lactatemax 10.6 $\pm$ 0.6 vs 12.9 $\pm$ 0.9 mmol/L ( $p < 0.05$ ); RER: 1.02 $\pm$ 0.04 vs 1.14 $\pm$ 0.05 ( $p < 0.05$ ).

#### CONCLUSION:

A higher VO<sub>2</sub>peak in active bodybuilders means that physical activity/training improves oxygen uptake. Lower blood lactate and RER values mean that they have more active lipid oxidation metabolism and oxidize a greater proportion of lipids respectively than inactive participants. Comparable results have been found in studies of Milanović Z et al-1 & Ramos-J et al.

Active bodybuilders showed significant higher VO<sub>2</sub>peak, lower RER values and lower blood lactate concentrations than inactive non-bodybuilders. The data demonstrate that these parameters can be used to quantitatively assess physical fitness of sport athletes in Pakistan on a larger scale.

References: 1-Milanović Z, Pantelić S, Sporiš G, Mohr M, Krstrup P. Health-related physical fitness in healthy untrained men: effects on VO<sub>2</sub>max, jump performance and flexibility of soccer and moderate-intensity continuous running. PloS one. 2015;10(8).

### EFFECTS OF DIFFERENT VELOCITY LOSS THRESHOLDS DURING THE SET ON LEG STRENGTH AND JUMP PERFORMANCE

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#### INTRODUCTION:

Velocity loss (VL) has been considered an accurate variable to measure neuromuscular fatigue during resistance training (RT) [1]. For that reason, several studies have analyzed the effects of different VL thresholds (20% vs. 40% and 5% vs. 20%) on strength gains and athletic performance [2,3]. However, further studies considering a wider spectrum of VL thresholds are needed. Therefore, the aim of this study was to analyze the effects of a wide spectrum of VL thresholds (0% (VL0), 10% (VL10), 20% (VL20) and 40% (VL40)) on leg strength and jump gains.

#### METHODS:

Forty-five physically active men were randomly assigned to four groups: VL0 (n= 12), VL10 (n=10), VL20 (n=13) and VL40 (n=10). Subjects followed an eight-week (twice per week) RT program using the full squat (SQ) exercise while monitoring movement velocity for every repetition, using a linear velocity transducer. Four groups trained from 55 % to 70% 1RM and RT programs only differed in the magnitude

of the VL induced during the set (0%, 10%, 20%, and 40%). Pre- and post-training assessments included countermovement jump (CMJ), and a progressive loading test in the SQ exercise until the velocity was less than 0.5 m•s<sup>-1</sup>. Variables derived from this test were: 1RM, average MPV attained against all absolute loads common to pre- and post-training (AV) and average MPV attained against absolute loads that were moved faster and slower than 1 m•s<sup>-1</sup> at Pre-training (AV>1 and AV<1, respectively).

**RESULTS:**

Significant group x time interactions ( $p<0.05$ ) were observed for 1RM and AV>1. No significant group x time interactions were observed for the rest of parameters analyzed. All groups attained significant improvements in 1RM (VL0: 11.7%, VL10: 10.2%, VL20: 20.4% and VL40: 10.7%,  $p<0.001$ ) and AV>1 (VL0: 15.5%, VL10: 13.6%, VL20: 23.9 % and VL40: 9.1%,  $p<0.001-0.01$ ). Significant enhancements were also found in CMJ height for all groups (VL0: 8.9%, VL10: 10.4%, VL20: 7.5% and VL40: 7.3%,  $p<0.001$ ).

**CONCLUSION:**

A moderate VL threshold (i.e. 20%) induces greater gains in 1RM and velocity against heavy loads (AV<1) in SQ than too low or excessive VL thresholds during the set.

**References:**

- 1-Sánchez-Medina & González-Badillo. Med Sci Sports Exerc. 2011
- 2-Galiano, C., et al. J Strength Cond Res 2020.
- 3-Pareja-Blanco, F., et al. Scan J Med Sci Sports. 2017

**THE EFFECT ON MUSCLE ACTIVITY AND FORCES OF PERFORMING A BULGARIAN SQUAT UNDER STABLE, UNSTABLE AND SUSPENDED CONDITIONS**

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**INTRODUCTION:**

The Bulgarian squat is a functional exercise aimed at improving lower body strength [1]. Likewise, Bulgarian squats are often performed under unstable or suspended conditions to increase muscular demands and provide more varied and effective training stimuli [2,3]. However, the effects of instability or suspension training on the lower limb have not been widely investigated. Therefore, this study aimed to compare muscle activation and the forces exerted on a suspension strap under different Bulgarian squat conditions.

**METHODS:**

Ten physically female athletes (age = 21.80±1.42 y, height = 1.72±0.05 m, body mass = 58.51±6.64 kg) were recruited to perform five repetitions of a Bulgarian squat, Bulgarian squat-Bosu-down (front leg on the BOSU with the dome side down), suspended-lunge (rear leg leaning within the suspension device cradle), and a suspended-lunge-Bosu-down. Surface electromyography was used to measure the muscle activation (BIOPAC MP-150) expressed as root mean square in microvolts (mV). The analysis included rectus femoris (RF), biceps femoris (BF), gluteus medius (Gmed), gluteus maximus (Gmax), vastus medialis (VM), and vastus lateralis (VL) muscular activity, and global activation (GL; average of all analysed muscles). Forces exerted on the suspension strap were measured with a load cell (Phidgets) and were expressed as % of body mass resistance. A one-way repeated measures ANOVA was used to determine the exercise effects under each different condition. A paired t-test was carried out to compare the force exerted on the suspension strap under exercise conditions.

**RESULTS:**

Main effects of every exercise condition were found on muscle activation of VL [ $F(3,27)=6.270$   $p=0.002$ ], Gmed [ $F(3,27)=7.937$   $p=0.001$ ], and GL [ $F(3,27)=10.132$   $p=0.000$ ]. The pairwise comparison showed that suspended-lunge-Bosu-down increased the activation of VL in comparison with Bulgarian squat-Bosu-down ( $p=0.036$ ) significantly. The Gmed activation was significantly higher in the suspended-lunge-Bosu-down than in the Bulgarian squat ( $p = 0.015$ ) and suspended-lunge ( $p=0.027$ ). The GL activation was significantly higher in the suspended-lunge-Bosu-down respect Bulgarian squat ( $p=0.001$ ) and Bulgarian squat-Bosu-down ( $p=0.000$ ). The suspended-lunge-Bosu-down reached a significantly lower force exerted on the suspension strap than the Bulgarian squat ( $t(9) = 2.339$ ,  $p = 0.044$ ).

**CONCLUSION:**

According to previous studies [2,3], these findings suggest that performing a Bulgarian squat under unstable or suspended conditions is as demanding as a traditional Bulgarian squat. The addition of an unstable surface in the forward leg provides the necessary amount of instability to increase the muscle activity in the suspended-lunge, although the forces exerted on the suspension strap decrease.

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Contact

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**COMPARISON BETWEEN VARIABLE AND CONSTANT LOAD DURING CHRONIC RESISTANCE TRAINING TO IMPROVE PERFORMANCE IN TEAM SPORT PLAYERS.**

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**INTRODUCTION:**

Traditionally, efforts to enhance athletic performance using resistance training (RT) have emphasized the concentric (CON) phase of the movement. However, many movements that can be seen in a range of athletic disciplines require eccentric (ECC) contractions and, hence, it would make sense to include this strength manifestation in RT regimes. In addition, most movements in the field require players to produce forces in variable and unpredictable contexts. Thus, in addition to conventional exercises, the inclusion of exercises that contain movements with an emphasis on ECC actions and a certain degree of variability might be useful when programming RT. Therefore, this study aimed to compare the chronic effects of two Eccentric Overload (EO) RT programs, with and without the application of variable inter-set load, on physical performance.

**METHODS:**

Sixty-three physically active men (age: 23.0 ± 3.0 years; height: 171.3 ± 23.4 cm; body-mass: 78.0 ± 18.0 kg) were randomly allocated to one of three groups: “constant training load” group (CLG: n=21); “variable training load” group (VLG: n=21); or control group (CG: n=21). The two experimental groups performed 4 sets of 7 repetitions of half-squat EO training twice per week. The intensity was adjusted in each set in order to obtain inter-set load variability. EO was achieved for every repetition because the device employed for the training allows

the use a higher load for the eccentric phase of the movement. Counter movement jump (CMJ), 20m sprint and change of direction abilities (V-Cut) were tested for pre- and posttest. We also measure foot contact time (CT) and flight time (FT) during 20m sprint in both test days. In addition, RPE was estimated using the OMNI-RES scale after every RT session in order to examine perceived exertion responses between groups. CMJ performance was also measured pre and post-session 3 and 7 with the aim of finding any post-activation potentiation (PAP) response.

**RESULTS:**

No substantial differences were found in any variables among the three groups for PRE. Within-group comparisons showed improvements in CMJ for VLG ( $p=0.014$ ) and CLG ( $p=0.005$ ). CT was impaired for VLG ( $p=0.034$ ). PAP response did not increase performance with 2:4 IU for VLG ( $p=0.013$ ) and CLG ( $p=0.02$ ). PAP response with 4:8 IU was impaired only for CLG ( $p=0.015$ ). CG showed no significant change in any parameter studied. Between-groups comparisons showed significant improvement on V-cut time for CLG over CT ( $p=0.046$ ) but not over VLG ( $p=0.414$ ). RPE showed differences only for session 12 ( $p=0.008$ ).

**CONCLUSION:**

Performing squats during RT with EO appears to be a good strategy to improve physical performance. However, the results of this study do not suggest that increasing the load variability during RT will bring better results, it is possible that very high levels of variability may cause undesired adaptations. Furthermore, the use of half-squat exercises during RT with EO may not be optimal for increasing sprint performance.

### THE EFFECT OF STRENGTH TRAINING ON DOUBLE POLING PERFORMANCE IN ADOLESCENT CROSS-COUNTRY SKIERS

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**INTRODUCTION:**

Generally, it is accepted that both strength and endurance abilities are needed in XC skiing, however recent developments in XC skiing have raised the importance of strength training (Losnegard 2019). As consequence, heavy strength training for improving strength abilities has attracted interest, both in research and in practical situations (Sandbakk 2018).

**METHODS:**

Twenty-eight adolescent competitive cross-country skiers and biathletes (age  $17.9 \pm 1.8$  y; body mass  $69.6 \pm 9.8$  kg; training experience  $8.6 \pm 3.2$  y;  $VO_{2max}$   $56.6 \pm 7.5$  ml/min/kg) participated in 10-week intervention during their preparatory period. Pre- and post-intervention performance was measured with graded exercise test (Max W) on the double poling ski ergometer, 5-pull maximum (5T) and 30 second (30T) tests were carried out. Athletes were divided into three intervention groups. Block (BLK) group performed maximal and explosive strength trainings in concentrated strength blocks alternating either 1 or 3 strength sessions per week, while linear (LIN) group performed maximal and explosive strength trainings two times per week throughout 10 weeks. Traditional (TRAD) group did endurance-strength type strength trainings with low weights and high number of repetitions 2-3 times per week.

**RESULTS:**

No difference was found between the number of strength training sessions ( $p<0.05$ ). In performance tests all groups improved their graded exercise performance (W) and  $VO_{2max}$  by 7.8 - 10.3 % and 1.7 - 9.9 %, respectively ( $p<0.05$ ). Improvement percentage in  $VO_{2max}$  was significantly higher compared with TRAD ( $p<0.05$ ). 5T performance was improved in BLK and TRAD group by 8 and 8.5 % respectively ( $p<0.05$ ) and 30T performance was improved in BLK ( $p<0.05$ ). Performance at the intensity second ventilatory threshold was significantly improved in TRAD and BLK groups ( $p<0.05$ ).

**CONCLUSION:**

Results from our study indicated all three strength training methods to be effective for developing adolescent XC skiers work capacity on double poling ergometer, however only BLK was found to be effective for both 5T and 30T,  $VO_{2max}$  and Max W.

### LOAD-VELOCITY RELATIONSHIPS IN A BENCH PRESS VARIATION: WEIGHT STACK MACHINE

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**INTRODUCTION:**

In the first decade of the twenty-first century, several studies verified that each relative load (percentage of one-repetition maximum, %1RM) corresponds to a certain velocity [1]. So far, the load-velocity relationship has been studied for different exercises [2]. Although the bench press (BP) exercise is typically performed using a WSM, no previous studies have analyzed the load-velocity relationship in this BP variant (BP-WSM). The purpose of this study was to investigate the load-velocity relationship during BP-WSM exercise.

**METHODS:**

Twenty-six men (age:  $22.3 \pm 3.4$  years; body mass:  $73.4 \pm 5.5$  kg; height:  $1.73 \pm 0.07$  m) performed a BP-WSM progressive loading test to determine their one-repetition maximum (1RM) and load-velocity relationship. A WSM device (Life Fitness Fit 3 Multi Gym, Chicago, IL, USA) was used for these measurements.

**RESULTS:**

The second-degree polynomial equation obtained from the relationship between relative load (%1RM) and mean propulsive velocity (MPV) was:  $MPV = -0.00001 \cdot \%1RM^2 - 0.0127 \cdot \%1RM + 1.5527$  with  $R^2$  of 0.972 and standard error of estimate = 0.065 m·s<sup>-1</sup>. The average value of the coefficient of determination of the adjustments of each subject was  $R^2 = 0.996 \pm 0.003$  (95% confidence interval = 0.995 - 0.997; coefficient of variation = 0.33%). The MPV associated with each %1RM was obtained from these polynomial fits, from 30% 1RM onwards, in 5% increments. The MPV at which 1RM was attained was:  $0.17 \pm 0.03$  m·s<sup>-1</sup>.

**CONCLUSION:**

The close relationship between the MPV values and the percentages of 1RM throughout the entire range of loads in BP-WSM exercise enables coaches to use the MPV to accurately monitor their athletes on a daily basis and accurately determine their actual 1RM in this exercise.



## THE RELIABILITY OF A NOVEL, EXPLOSIVE ISOMETRIC MID-THIGH PULL AND COMPARISON OF FORCE TIME VARIABLES WITH THE TRADITIONAL ISOMETRIC MID-THIGH PULL

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### INTRODUCTION:

Strength and rate of force development (RFD) are key determinants of athletic performance (Brazier et al. 2018). The maximal Isometric Mid-Thigh Pull (mIMTP) is a popular test to assess isometric peak force (PF) and RFD. RFD is calculated in the first 250 milliseconds of a contraction (McMaster et al. 2014). It is proposed that the mIMTP is inappropriate to assess RFD due to the prolonged contraction (usually 3-6 seconds). A novel, explosive IMTP (eIMTP) is offered as an alternative to assess RFD. The aim of this study was to assess the reliability of the eIMTP and mIMTP and compare PF and RFD between contraction types.

### METHODS:

Following two familiarisation sessions, eighteen healthy adults (10 males, 8 females) performed both the eIMTP and mIMTP on two separate days, separated by 48 hours. Both were cued to "pull as hard and as fast as possible". Knee and hip angle were self-selected and standardised between sessions. For the eIMTP, participants were instructed to pull for "less than 1 second" and performed ten repetitions each day. For the mIMTP, the participants were instructed to "pull for 5 seconds" and performed three repetitions each day. On each day, the trial with the highest PF in the mIMTP and the trial with the highest peak RFD (pRFD) in the eIMTP were selected for analysis. pRFD was calculated using 20ms epochs. Reliability was assessed by intraclass correlation coefficient (ICC) and coefficient of variance (CV). A two-way repeated measures ANOVA was used to assess group differences. Effect size (ES) was expressed as partial eta squared. Level of significance  $p < 0.05$ .

### RESULTS:

There was a significant interaction effect on pRFD ( $F_{1,17}=4.894$ ,  $P=0.041$ ,  $ES=0.639$ ). Simple main effects for contraction type showed pRFD was significantly higher in the eIMTP on day 1 ( $F_{1,17}=25.617$ ,  $P<0.0005$ ,  $ES=0.601$ ) and day 2 ( $F_{1,17}=29.422$ ,  $P<0.0005$ ,  $ES=0.634$ ). There was no change in pRFD over time in the eIMTP or mIMTP ( $F_{1,17}=3.769$ ,  $P=0.069$ ,  $ES=0.181$ ;  $F_{1,17}=1.312$ ,  $P=0.268$ ,  $ES=0.268$ , respectively). There was a significant main effect for contraction type on PF ( $F_{1,17}=27.507$ ,  $P<0.0005$ ,  $ES=0.618$ ). PF was significantly higher in the mIMTP. There was no main effect for time ( $F_{1,17}=0.289$ ,  $P=0.598$ ,  $ES=0.017$ ) and no interaction effect on PF ( $F_{1,17}=2.449$ ,  $P=0.136$ ,  $ES=0.126$ ). Both pRFD and PF were highly reliable in the eIMTP (ICC=.894, CV=6.44-10.58%; ICC=.946, CV=3.2-5.8%, respectively). In the mIMTP, PF was reliable (ICC=.763, CV=1.89-4.71%) but, reliability was low for pRFD (ICC=.447, CV=11.24-28.36%).

### CONCLUSION:

The eIMTP resulted in reliable pRFD measures that were significantly higher than the mIMTP. This indicates that the eIMTP may be a more appropriate measure of RFD and should be preferred when assessing RFD. However, the mIMTP resulted in reliable PF measures that were significantly higher than the eIMTP and therefore should be preferred when assessing maximal isometric strength. Results from both contraction types should be used collectively to inform strength and conditioning programs

## COMPARED THE LOAD-VELOCITY RELATIONSHIP BETWEEN PARALLEL AND BULGARIAN SQUAT

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### INTRODUCTION:

Parallel squat (P-SQ) is the multi-joint, compound movement to develop lower limb and core strength, Bulgarian squat (B-SQ) is an important supplement exercise to improve single-leg control ability. However, it is hard for coaches to assess maximum strength of P-SQ and B-SQ using traditional 1 repetition maximum (1RM) method in one training session. Velocity based training method which is using velocity-load relationship to regulate exercise intensity and monitor fatigue was proved validly and reliability. The purpose of this study is to determine whether load-velocity relationship of P-SQ can be used to monitor dominant leg Bulgarian squat (D-BSQ) and non-dominant leg Bulgarian squat (N-BSQ) training by comparing the velocity differences of each relative load between P-SQ and B-SQ.

### METHODS:

In the experiment of this study, 17 men performed 1 repetition maximum (1RM) and 2 bar velocity test sessions, respectively for P-SQ, D-BSQ and N-BSQ. After assessed 1RM, concentric velocity values were collected in 2 bar velocity test sessions randomly. One session contained 3 repetitions  $\times$  20% 1RM, 3 repetitions  $\times$  40% 1RM, 3 repetitions  $\times$  60% 1RM and 3 sets  $\times$  1 repetition  $\times$  80% 1RM, the other one session contained 3 repetitions  $\times$  30% 1RM, 3 repetitions  $\times$  50% 1RM, 3 repetitions  $\times$  70% 1RM and 3 sets  $\times$  1 repetition  $\times$  90% 1RM. The velocity differences at each sub-maximum load of every two squats were compared through a paired-sample t-test and effect size.

### RESULTS:

This study found significant differences between P-SQ and D-BSQ or N-BSQ in mean, peak velocity at sub-maximum load, except mean velocity of 80%, 90% 1RM of D-BSQ. Furthermore, this study compared the velocity variables difference between both leg Bulgarian squat, significant difference in mean velocity were observed at 20%, 50% 1RM.

### CONCLUSION:

This study believed different squats influenced biomechanics, dynamic joint stability and development of force. In addition, subjects need to break up more strength to maintain stability in single-leg squat than parallel squat. Through longtime practice, the dominant leg can better control single-squat movement such as body stability and development of force than non-dominant leg.

The result believed that the load-velocity relationship of P-SQ cannot be used to monitor Bulgarian squat exercise and both leg velocity variables seemed similar for most load.

## EFFECTS OF LONGER TIME UNDER TENSION IN STRENGTH TRAINING ON STRENGTH AND BODY COMPOSITION

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### INTRODUCTION:

Millions of members enrolled in gyms, aim to build muscle mass through targeted strength training. So far, it has been recommended without scientific proof to keep the number of repetitions low and not to perform more than 8-12 repetitions per set. It is now assumed that more effective hypertrophy can be achieved by a longer time under tension. However, there exist no satisfactory scientific evidence.

Therefore, the aim of this study was to examine the effects of different periods under muscle tension in order to derive training recommendations for practice.

#### METHODS:

Data from 84 male subjects (age: 24±5 years, height 181.9±7.3cm, body weight:74.2±11.1kg, lean body mass: 61.8±8.1kg) who were inexperienced in strength training were included in the analysis. They completed a standardized training program 3 times a week for 12 weeks with each exercise until subjective exertion. Five different training programs (TP; n=14±3 in the groups) and a control group (CG) were compared: 1. one set with 90sec load and additional protein intake after the training (TP-90+), 2. one set with 90sec (TP-90), 3. one set with 60sec (TP-60), 4. two sets with 45sec load (TP-45x2), 5. 8-12 repetitions (corresponding to 38± 7sec (TP-8-12)). Before, during and after the intervention, the one-repetition maximum (1-RM) as well as the muscular endurance (ME) for the mm. pectoralis (Pec) and quadriceps (Quad), the body composition using bioelectrical impedance analysis (InBody Co., Seoul, South Korea) and muscle circumferences for chest, arm and leg were determined.

#### RESULTS:

Compared to CG, the 1RM and ME significantly increased in all training groups without significant differences between the 5 protocols. A tendency to highest augmentation for 1RM was found in TP-90 (9.0±8.9%; p<0.001) for Pec and in TP-8-12 (13.9±6.3%, p<0.001) for Quad. ME improved between 20.7±25.2% (TP-45x2, p<0.05) and 22.5±23.2% (TP-90, p<0.001) for Pec and 62.7±45.0% (TP-45x2, p<0.001) and 100.7±81.6% (TP-90, p<0.001) for Quad. Skeletal muscle mass increased significantly in four intervention groups in a range of 1.6±2.9% (TP-60, p<0.05) and 1.8±2.1% (TP-90, p<0.01) but no change occurred in TP-8-12 (0.5± 4.6%, p=0.8). Similar results were found for muscle circumferences of chest and arm. Except for TP-8-12 (chest: 1.1±1.7%, p=0.3; arm: 1.9±3.2%, p=0.2) the circumferences were significantly augmented compared to CG in the mean by 2.1±1.7% of the chest and 3.3 ±2.6% of the arm in all groups. For the leg no differences were found.

#### CONCLUSION:

Strength values of all intervention groups increased significantly after 12 weeks without differences between the groups. The muscle gain was significant in all TP-groups except for TP-8-12. For beginners in strength training, therefore, the time under tension seems not to be the decisive factor for strength development; but for hypertrophy, a longer time under tension of at least 60sec seems to be more effective than the traditional 8-12 repetitions.

## CP-AP05 Training and testing

### ANALYSIS OF THE MAXIMAL SPEED OBTAINED IN A INCREMENTAL TEST IN MIDDLE-DISTANCE MEN RUNNERS OF NATIONAL AND INTERNATIONAL LEVEL OVER TWO DIFFERENT SURFACES: A MOTORISED TREADMILL AND ATHLETIC TRACK

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#### INTRODUCTION:

Laboratory tests are assessment tools widely used in athletes, but the results obtained in the measured variables sometimes differ from those obtained in the athletes natural environment [1, 2, 3]. Several studies have analyzed the differences between both testing forms (with different types of treadmill grade [4]) in different sports population with more or less experience and level [1, 2, 3]. Therefore, the aim of this study was to analyze the differences in maximal speed (MS) performance in a test performed on a motorized treadmill or on a track in men runners of national and international level. In addition, to analyze the relationship with strength values and the differences between tests and the performance obtained.

#### METHODS:

10 middle-distance men runners (800 to 3000m) of national and international level (800m personal best range: 1:44-1:58) performed two MS tests, one on a motorized treadmill (MT) with a 1% grade and another on a athletic track (AT), separated by 48 hours. The test started at 8 km/h and progressively increased 0.5 km/h per minute. Athletes finished the test when they could not maintain the speed. The variables measured were: total time (MS\_t), maximum speed (MS\_spe), maximum (HRmax) and average (HRavg) heart rate, lactate concentration [L] (3 min after the end of the test) and the initial and final countermovement jump (CMJ), calculating the jump loss (CMJ\_loss). Additionally, athletes performed strength related tests: squat (SQ), squat jumps (SJ) and speed (SP) over 0-10, 10-20 and 0-20m in a separated day from the two MS tests.

#### RESULTS:

Significant differences were found in MS\_t and MS\_spe between MT and AT (p < 0.01), with higher MS\_t and MS\_spe in MT. No significant differences were found in HRmax, HRavg, Initial CMJ, CMJ\_loss, and L. In addition, CMJ\_pre, CMJ\_post, SQ, SJ showed a significant positive relationship (p < 0.05) with the MS\_t and MS\_spe. Speed (0-10m) showed a significant positive correlation with the loss of MS\_spe and MS\_t. (p<0,05).

#### CONCLUSION:

Differences on MS performance were found when test was performed on a MT versus an AT in middle-distance men runners of national and international level. Higher total time and speed were observed when the test was performed on the MT compared to the AT although both produced the same degree of effort represented by the HR values, CMJ loss and L concentration. In addition, athletes with better strength performance, achieved better MS performance despite having greater loss of MS between test. Differences in performance between two MS test could quantify the effect of air opposition to displacement and the effect of acceleration for the same degree of fatigue [4, 5].

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## PHYSICAL ACTIVITY OF ADULT KENYAN AND ETHIOPIAN HIGH LEVEL DISTANCE RUNNERS COMPARED TO NON-ATHLETES

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### INTRODUCTION:

Many non-communicable chronic health conditions prevalent in both developed and developing countries are associated with physical inactivity. Physical activity (PA) has been well-studied among different age groups in children and adolescent, however information about PA levels of adults, specifically from the area of East Africa is scarce. The aim of the present study was to compare weekly PA in athletes and non-athletes from Kenya and Ethiopia.

### METHODS:

7 day physical activity was objectively measured using ActiGraph accelerometer model GT3X (ActiGraph LLC, Penascola, FL, USA) from a total of 53 competitive male runners (26 Kenyans and 27 Ethiopians, 25.8±4.5 yrs; 57.9±6.0 kg and 1.72±0.06 m) and 43 non-athletes (26 Kenyans and 17 Ethiopians, 25.7±5.3 yrs; 63.9±8.0 kg and 1.69±0.08 m) and 35 female runners (18 Kenyans and 17 Ethiopians, 26.3±6.5 yrs; 51.6±4.5 kg and 1.62±0.06 m) and 40 non-athletes (21 Kenyans and 19 Ethiopians, 27.3±5.8 yrs; 61.2±10.0 kg and 1.66±0.06 m). Average daily PA was calculated.

### RESULTS:

The average daily moderate to vigorous PA (MVPA) for male runners was 48 minutes higher compared to non-athletes (133±40 vs 85±45 min respectively,  $p<0.005$ ), and for female runners 64 minutes higher compared to non-athletes (121±33 vs 57±25 min respectively,  $p<0.005$ ). Female runners had significantly ( $p<0.005$ ) more sedentary time compared to male runners (477±121 vs 433±76 min respectively) and male non-athletes were had more sedentary time (488±117min,  $p>0.05$ ) compared to male athletes. Female controls had significantly higher weekly average of light activity minutes ( $p<0.05$ ) compared to female runners and male non-athletes (316 ± 90 vs 258 ± 50 vs 247 ± 74 min respectively).

### CONCLUSION:

Our findings show that the PA levels of East African runners and non-athletes are in good level. Expectedly we found higher MVPA levels on athletes. Additionally, no difference in female runners sedentary time compared to non-athletes was noted, while male non-athletes accumulated higher level of sedentary time compared to athletes. It would be interesting to compare this very unique adult East African population PA patterns with Caucasian distance runners and controls.

Keywords: Physical activity, Accelerometer, Athletes, East African runners

## CHANGES IN ENERGY BALANCE AND BODY COMPOSITION FOR 3-YEAR ATHLETIC SEASONS IN JAPANESE COMPETITIVE GIRL RUNNERS.

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### INTRODUCTION:

It is important for long distance runners to decrease fat mass (FM) without losing fat free mass (FFM) during weight loss. The change in body composition is determined by that of energy balance (EB). However, the question how body composition and EB will change over a season has not been addressed on adolescent runners. The purpose of this study was to assess changes in EB and body composition for 3 years in Japanese competitive girl runners.

### METHODS:

The data of body composition were obtained from consecutive 25 freshmen (H1; 15.0y/o, 159.0cm, 47.3kg), 14 juniors (H2; 15.9y/o, 160.4cm, 46.0kg), and 8 seniors (H3; 16.9y/o, 160.6cm, 45.6kg) in the same girl's high school team and were retrospectively analyzed at 3 time points; preparatory (PRE), mid-competitive (CMP1), and the end of competitive (CMP2) seasons. The team regularly participated in the All-Japan high school Ekiden championship. Among the data of the 25 H1 runners, 7 runners who also had the data of H2 and H3 were assessed 3-year changes in EB and body composition. Body composition was measured by DXA and change (c) in EB (kcal/day) was evaluated by the following formula  $1.0*(cFFM/cDays) + 9.5*(cFM/cDays)$ . Repeated measure ANOVA was used to compare body composition among 3 time points of the each grade-group. Regarding the 7 runners, body composition among 9 time points were compared by contrast analysis. Written informed consents were obtained from the runners and their parents.  $P<0.05$  was considered as statistically significant.

### RESULTS:

FM was significantly decreased from PRE to CMP1, but did not change from CMP1 to CMP2 in all grade-groups (H1; 9.4±3.4, 5.6±1.5, 6.3±2.2, H2; 6.6±1.7, 5.4±2.0, 6.3±2.1 and H3; 6.3±1.1, 4.0±1.3, 5.6±2.4kg, respectively). FFM was significantly increased from PRE to CMP1 in H1 and H2, but not in H3 (H1; 37.4±3.5, 39.2±3.8, H2; 39.3±3.6, 40.1±3.8, and H3; 39.2±3.9, 39.8±4.4kg, respectively). FFM did not change from CMP1 to CMP2 in all grade groups (H1; 39.2±3.8, 39.1±3.7, H2; 40.1±3.8, 39.9±3.6, and H3; 39.8±4.4, 39.6±4.8kg, respectively). The large negative EB occurred in H1 than in H2 and H3 from PRE to CMP1 (H1; -200.2±153.6, H2; -63.8±89.4, and H3; -118.8±64.4kcal/day, respectively). EB was positive from CMP1 to CMP2 in all grade groups (H1; 54.6±134.2, H2; 65.5±99.7, and H3; 118.1±109.9 kcal/day, respectively). The seasonal trend of the changes in body composition and EB were depicted in 3-year observation of the 7 runners.

### CONCLUSION:

Competitive adolescent runners could decrease FM without losing FFM with negative EB. Even with large negative energy balance occurred in the freshmen year. The trend of the periodic changes of EB and body composition were confirmed by 3-year follow-up in the same individual. Leanness could be achieved by not only losing FM but also gaining FFM during negative energy balance.

## RELATIONSHIP BETWEEN BODY SEGMENT MASS AND RUNNING PERFORMANCE IN ENDURANCE RUNNERS

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### INTRODUCTION:

Endurance runners are required to having lower body mass than that of many athletes to perform economical running (Anderson, 1996). Of body segments, smaller leg mass may be an essential characteristic for successful endurance runners because it decreases the energy cost during running, particularly during swinging of the legs (Black et al., 2019). In contrast to the leg mass, because it is the fact that hip extension and flexion torques while running play important roles in achieving superior running performance (Novacheck, 1998), greater

trunk mass (i.e., greater hip extension and flexion muscles) may also be an essential characteristic for successful endurance runners. Therefore, we hypothesized that smaller leg mass and greater trunk mass would be related to higher running performance. To test our hypothesis, we examined the relationships between body segment masses and running performance in endurance runners.

**METHODS:**

Thirty-eight male endurance runners participated in this study. Body composition and segment masses (i.e., legs, arms, and trunk masses) in the subjects were measured using dual-energy x-ray absorptiometer (DXA). Total (included muscle, fat, and bone masses), lean (excluded fat and bone masses from the total mass), and fat masses evaluated in each segment. In addition to absolute segment mass, relative segment mass which normalized to body mass was used for analysis of this study.

**RESULTS:**

Physical characteristics (e.g., body height and mass) and body composition (e.g., percent fat mass and whole-body muscle mass) did not correlate significantly with personal best 5000-m race time. No significant correlation was also observed between all absolute segment masses and personal best 5000-m race time. Moreover, there were no significant correlations between the relative fat masses of all three segments and personal best 5000-m race time. By contrast, the relative total masses of the legs and trunk correlated positively and negatively, respectively, with personal best 5000-m race time ( $r = 0.413$  and  $-0.469$ ,  $P < 0.05$  for both). Similarly, the relative lean masses of the legs and trunk correlated positively and negatively, respectively, with personal best 5000-m race time ( $r = 0.357$  and  $-0.542$ ,  $P < 0.05$  for both). Furthermore, ratios of the total and lean masses of the legs relative to the trunk correlated positively with personal best 5000-m race time ( $r = 0.464$  and  $0.530$ , respectively,  $P < 0.05$  for both).

**CONCLUSION:**

The present study determined that smaller leg mass and greater trunk mass are related to higher running performance. These findings suggest that a balance between the leg and trunk segment masses may be an important factor in achieving superior running performance in endurance runners.

**INFLUENCE OF FOOTWEAR WEIGHT ON PERFORMANCE AND ENERGY COST IN TRAINED RUNNERS.**

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**INTRODUCTION:**

The effect of footwear on running performance is a growing interest area [1]. Footwear properties such as mass, midsole composition and longitudinal bending stiffness have been shown to affect the energy cost (EC) of running [2]. However, there are few studies that determine the effect of footwear on performance variables [1] such as the time up to exhaustion test (TLimT). The purpose of this study was to analyse the influence of footwear in a performance test at intensity of  $v\dot{V}O_{2max}$  and the EC of running at submaximal intensities.

**METHODS:**

With institutional ethics approval, eleven trained distance runners (mean  $\pm$  SD:  $\dot{V}O_{2max}$   $65.62 \pm 7.04$  ml $\cdot$ kg $^{-1}\cdot$ min $^{-1}$ , age  $21.22 \pm 1.3$  years, weight  $56.57 \pm 9.11$  kg, height  $166.45 \pm 7.86$  cm) completed three TLimT ( $v\dot{V}O_{2max}$ ) in order to evaluate the performance, preceded by a warm-up of 15 min (3x5 min) at intensities corresponding with the 75, 85 and 95% of the VT2 (1% gradient) to evaluate the EC of running. The three tests were performed under the different conditions of footwear weight gain (control, +50 g, +100 g) in a cross-over experimental design.

**RESULTS:**

EC significantly increase ( $p < 0.05$ ) with the increment of footwear weight (Control vs 100g) at 85% (4.39 and 4.71 kJ $\cdot$ kg $^{-1}\cdot$ km $^{-1}$ ) and 95% (4.28 and 4.69 kJ $\cdot$ kg $^{-1}\cdot$ km $^{-1}$ ) of VT2 intensity, but there were not differences between 50 g vs 100g neither between Control vs 50g at any intensity. At the performance test, TLimT remained without significant changes ( $p < 0.05$ ) between footwears weight, although the TLimT of Control condition was  $\sim 40$  s higher than 100g ( $185.91 \pm 45.89$  s and  $145.00 \pm 42.82$  s;  $ES = 0.922$ ) and  $\sim 15$  s than 50g ( $185.91 \pm 45.89$  s and  $169.30 \pm 49.63$  s;  $ES = 0.347$ ).

**CONCLUSION:**

The results suggest that use of a heavier footwear (100 g extra) could impairs performance about 20% ( $ES = 0.922$ , for Control vs 100g). In addition, EC increase with higher weight addition (100g) at submaximal intensities, similar to previous study [3]. On the base of this data, the footwear weight influences on the EC and performance in trained runners.

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**CP-AP06 Swimming**

**QUANTITY AND QUALITY OF SKELETAL MUSCLE IN FEMALE COLLEGE SWIMMERS ACCORDING TO COMPETITION TYPE**

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**INTRODUCTION:**

Skeletal muscle mass and body fat mass are common indicators for determining the condition of athletes. Methods for measuring skeletal muscle mass and body fat mass include bio-impedance analysis, magnetic resonance imaging, and ultrasonography. Ultrasonography can also be used to measure intramuscular adipose tissue (IMAT) using echo intensity (EI). Although IMAT is thought to be more common in elderly individuals, few studies have assessed IMAT in athletes. Moreover, muscle thickness (MT) and subcutaneous fat thickness (SFT) in the thigh, upper arm, and abdomen have been studied in swimmers; however, the MT, SFT, and EI of body parts according to competition type among swimmers are not clear. We aimed to investigate the MT, SFT, and EI of swimmers according to competition type using ultrasonography.

**METHODS:**

The participants were 8 Japanese female college swimmers, and considering the characteristics of the competition type, they were divided into the breaststroke(BR) and non-breaststroke(NBR) groups: [4 BR; age: 20.5±1.1 years, body weight (BW): 55.8±5.0 kg, body fat percent (BF%): 22.2±2.0%, 4 NBR; age: 20.0±1.0years, BW: 59.6±5.9 kg, BF%: 24.1±1.6%]. BW, BF%, and fat-free mass were measured using bio-impedance analysis (Inbody 770). MT and SFT were measured using B-mode ultrasonography, and the ultrasonic frequency measurement was set at 8 MHz. EI was measured using imagej software. The measurement sites were the front and back sides of the right thigh, front and back sides of the lower thigh, two places on the abdomen, forearm, and front and back sides of the upper arm. The front of the thigh and upper arm were measured on the left and right sides, and a total of 11 measurements were acquired. EI of the rectus femoris, biceps femoris, extensor digitorum longus (EDL), gastrocnemius, flexor carpi radialis, biceps brachii, triceps brachii (TB), rectus abdominis, and external oblique were measured. The measurements were performed after resting for 30 minutes so that the MT and SFT were not affected.

**RESULTS:**

There were no significant changes in both groups regarding body composition measured by bio-impedance analysis. However, there were significant changes in both groups regarding body composition measured by ultrasonography. The MT of the back of the thigh increased significantly in the NBR group compared to that in the BR group ( $P=0.029$ ), but there were no significant differences in SFT. The EIs of EDL ( $P=0.049$ ) and TB ( $P=0.015$ ) were significantly higher in the NBR group than in the BR group.

**CONCLUSION:**

The quantity and quality skeletal muscle in female college swimmers differ according to competition type.

**RELATIONSHIPS BETWEEN AGE, EXPERIENCE AND PERFORMANCE ON ELITE OPEN WATER COMPETITION**

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**INTRODUCTION:**

Since 2008 Beijing Olympic Games, open water races represent a discipline of the Olympic program, specifically the 10Km events. Open water are tactical events, where race decisions of swimmers based on surrounding counterparts, external race conditions, the participants experience, and the own fatigue levels have a great impact on results [1]. Indeed, competitors do not look for the best possible finishing time but the best finishing position. Therefore, the aim of the present research was to determine the relationship between age of participants (as well as years of experience) and the finishing positions of open water elite swimmers.

**METHODS:**

In all 10Km events of World Championship and Olympic Games since year 2000, final ranking and age of participants were collected from public domain. The final data was composed by 639 female entries and 738 male entries and comprised 1235 and 142 entries for the World Championship and Olympic Games, respectively. Competitors were divided into four groups (G1 to G4) depending on their finishing positions (G1: position 1-10; G2: 11-20; G3: 21-30; G4: 31-...) and also four groups depending on the years of experience (EXP1, EXP2, EXP3 and EXP4+ for one, two, three or more participations on elite open water events). Percentage of distribution of years of experience on the different finishing groups and correlation coefficients between age of participants, years of experience and finishing position in the 10Km races, both males and females were calculated.

**RESULTS:**

The percentage of distribution of the swimmers' years of experience on the different finishing groups (males and females) were 15.6% and 20.3% for EXP1, 27.4% and 22.6% for EXP2, 30.3% and 36.6% for EXP3 and 37.0% and 44.2% for EXP4+. For G2 the distribution was 17.5% and 25.6% for EXP1, 26.2% and 27.7% for EXP2, 27.0% and 32.9% for EXP3 and 34.5% and 27.3% for EXP4+. For G3, 24.7% of males and 21.4% of females had EXP1; 16.5% and 22.6% had EXP2; 12.4% and 11.0% had EXP3; and 17.6% and 14.3% had EXP4+. Finally, for G4 swimmers, 42.2% and 32.7% had EXP1; 29.9% and 27.0% had EXP2; 30.3% and 19.5% had G3; and 10.9% and 14.3% had EXP4+.

The relationships between swimmers' age and their finishing position were -0.34 for men and -0.29 for women, whereas relationships between the swimmers' years of experience and finishing position were -0.27 and -0.23 for men and women.

**CONCLUSION:**

Maximum percentage of successful participants (top-10) corresponded to swimmers with 4 or more years of experience in elite open water races. However, relationships between age or experience and finishing positions were low-to-moderate. Therefore, no strong correlations between success in open water events and age or experience was observed. However, there was a trend where the participants with more experience represented the greatest contribution to the successful participant groups.

**THE EFFECTS OF ASSISTED SWIM TRAINING USING ELASTIC TUBES ON BEGINNER COLLEGIATE SWIMMERS**

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**INTRODUCTION:**

Assisted swimming (AS) is traditional training focused on improving swimming skills for competitive swimmers. Moriyama et al. (1) reported that AS using a towing device for beginner collegiate swimmers increased swimming velocity. However, using a towing device for AS is not typical for daily swimming training because the elastic tubes are more convenient to bring somewhere and the cost is quite low compared to the towing machine. Therefore, in the present study, we examined the effect of AS using an elastic tube instead of the towing machine on beginner swimmers' performances.

**METHODS:**

Nineteen collegiate recreational swimmers (11 men, 8 women) participated in the study (height, 1.67 ± 0.08 m; weight, 60.5 ± 6.7 kg). The subjects were randomly divided into two groups: the AS group (TG, n=9; 5 men, 4 women) and the no-AS group (CG, n=10; 6 men, 4 women). All swimmers underwent five training sessions with 30 minutes per training session. All aspects of the training regimens were similar, with the exception of the use of an elastic tube in AS. The towing force was set at around 80N, and the same person towed the elastic tube in all trainings. Before and after the training, the swimmers performed a 25-m front crawl swim and a 25-meter resisted-sprint crawl swim using a towing device with maximal effort; they were photographed in the transverse plane from above on land in the streamline position. Participants' swimming velocity, stroke rate, stroke length, active drag (AD), and active drag coefficient (ADC) were calculated. The calculating AD and ADC scores were based on previous studies (2, 3).

**RESULTS:**

In the TG, stroke rate significantly increased (before,  $41.39 \pm 6.01$  cycle/min; after,  $44.88 \pm 4.94$  cycle/min,  $p < 0.05$ ) and other measurements did not change. However, no significant differences were observed in any of the measurements in the CG.

#### CONCLUSION:

Our results showing that stroke rate significantly increased support the findings of previous research (4). On the other hand, the fact that the swimming velocity did not increase contrasted with the results in another study (1). The assisted force of the towing device, which was set at 100N in a previous study (1), was much stronger than that using the elastic tube in the present study, which may explain why the results were different. In conclusion, the present study demonstrates that AS using elastic tubes with beginners increases their stroke rate, although it does not increase their swimming velocity.

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### RELATIONSHIP BETWEEN CHARACTERISTICS OF STATIC STREAMLINE POSTURE AND SWIMMING VELOCITIES OF TOWED STREAMLINE POSTURE

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#### INTRODUCTION:

When swimmers statically maintain a streamline posture in the water, the lower limb torque causes both legs to sink owing to the distance between the center of mass (CM) and center of buoyancy (CB) [1]. When swimmers propel in water, the water drag increases exponentially with swimming speed [2] and is affected by the trunk transverse surface area (TTSA) underwater [3]. It is not clear whether the indices obtained from a statically streamline posture influence the performance of propulsion. Therefore, the present study aimed to examine the relationships among the swimming velocity in the towed streamline posture, TTSA, distance between CM and CB, and leg sinking angle in the static streamline posture.

#### METHODS:

Eight well trained male collegiate swimmers performed four tests as follows; 1) maintaining the streamline posture (SL) in water using the towing machine at 26.7 N, 53.4 N, and 80.1 N towing force to measure the swimming velocity, 2) SL with both arms raised on a webbed steel frame in water and land to measure the position of CM and CB, 3) standing SL on land to measure TTSA, 4) SL gripping the stainless bar for measuring the leg sinking angle in water. CM and CB were expressed in terms of distance from the participant's foot. CM was measured by the reaction board method, which used load cells. CB was calculated using the force exerted in a vertical direction with four load cells attached to the hands and feet, respectively. The distance between CM and CB was determined as the difference between them. Pearson's correlation coefficients were calculated for swimming velocity and the other indices.

#### RESULTS:

Swimming velocities at 26.7N, 53.4N, and 80.1 N significantly increased with each towing force. TTSA, the distance between CM and CB, and the leg sinking angle were not significantly related to swimming velocities.

#### CONCLUSION:

The present study demonstrated that the indices expected to influence the passive drag, such as the TTSA, the distance between the CM and CB, and the leg sinking angle obtained in the static streamline posture, were not related to swimming velocities in the towed streamline posture.

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## CP-AP07 Football

### ONE-MINUTE HALF-TIME RE-WARM UP AT HIGH-INTENSITY MAINTAINS SPRINT PERFORMANCE IN THE INITIAL AND FINAL PARTS OF THE SECOND HALF

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#### INTRODUCTION:

Sprint performance, which is an important indicator for football players, decreases in the initial part of the second half [1]. To overcome this issue, a half-time re-warm up (RW) has been proposed [2]. A recent study reported that 1-min cycling-based RW at 90% of maximal oxygen uptake (VO<sub>2</sub>max) increased cycling sprint performance after simulated half-time [2]. However, assessing the cycling-based sprint performance has limited practical applications in actual matches. Moreover, this study did not investigate sprint performance in the final part of the second half. Therefore, the present study aimed to investigate the effect of 1-min RW at 90% of VO<sub>2</sub>max on running-based sprint performance in the second half.

#### METHODS:

Twelve physically active men (age, 22±2 years; height, 1.70±0.08 m; body mass, 65.1±8.3 kg and VO<sub>2</sub>max, 53.5±4.5 mL/kg/min) completed two experimental trials using a randomised cross-over design in thermoneutral environment (temperature, 15.9±2.4°C; humidity, 37.3±9.3%). In the experimental trials, participants performed the Loughborough Intermittent Shuttle Test (LIST) separated by a 15-min half-time. Participants were required to perform 6 exercise blocks of the LIST, consisting of walking, maximal sprint, jogging and running. In the half-time (i.e., between the 3rd and 4th blocks), participants performed either a 15-min seated rest (CON) or 1-min RW at 90% of VO<sub>2</sub>max after a 14-min seated rest. Sprint times, maximal voluntary contraction (MVC) force, electromyograms (EMG) and neuromuscular efficiency (NME) during MVC, gastrointestinal (T<sub>c</sub>) and skin (T<sub>s</sub>) temperatures and heart rate (HR) were measured.

**RESULTS:**

Compared with the CON, the RW maintained sprint time during the 4th and 6th blocks in the LIST (4th: 2.4%, p=0.002, 6th: 3.6%, p=0.012), increased mean HR in the initial 5 min of the 4th block in the LIST (4 bpm, p=0.016), decreased EMG amplitude during MVC after half-time (12.4%, p=0.017), and prevented decrements of T<sub>c</sub> (0.5°C, p=0.010) and NME (9.0%, p=0.048) during half-time. No significant differences between both trials was observed for MVC force and T<sub>s</sub> throughout the experimental trial.

**CONCLUSION:**

The present study revealed that the RW maintained sprint performance after half-time, which is consistent with a previous study [3]. Moreover, this study is, to our knowledge, the first to observe that the RW maintained sprint performance at the final part of the second half. These improvements are especially important for football players since the most frequent action in goal situations was straight sprinting [4]. Potential mechanisms contributing to the maintained sprint performance after half-time may be the maintenance of T<sub>c</sub> and NME during half-time. Moreover, increased VO<sub>2</sub> after half-time as evidenced by increasing HR may contribute to the maintenance of sprint performance in the final part of the second half.

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**ANALYSIS OF CUMULATIVE WEEKLY TRAINING LOAD AND ITS IMPACT ON MATCH PERFORMANCE: A PROSPECTIVE ANALYSIS IN ADULT SOCCER PLAYERS**

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**INTRODUCTION:**

The primary goal of training is to maximize match performance and avoid side effects as fatigue, injury, illness, and overtraining (1). To this scope, several studies report how an excessive increase in workload may produce cumulative fatigue, which has also been associated with risk of injury (2, 3). However, little is known about its effect on match performance. Therefore, this study aimed to analyze how the amount and variation of weekly training load impact on match performance.

**METHODS:**

Twenty male adult soccer players (means ± SD age of 22 ± 4.7 y) were monitored over a period of 19 weeks during in-season. The internal load (ITL) of all trainings and matches (n= 76 and 19, respectively) were quantified using the session-RPE method (s-RPE) obtained by multiplying the RPE value with minutes of training (4). Furthermore, during all matches, players wore global position devices with tri-axial accelerometers (JOHAN Sports, The Netherlands) to assess the following external training load (ETL) parameters: total distance (TD), sprint distance (SPD), high sprint distance (HSD), number of sprints (NOS), playerload2D (PL2D), playerload3D (PL3D), total acceleration (TAcc), total deceleration (TDec), high acceleration (HAcc) and high deceleration (HDec). Only players who played more than 65 minutes were included for further analysis. Rolling weekly sums of ITL of the last two weeks and the percentage variation with the previous two ones were modeled against ETL and analysed using a multivariate analysis of variance (MANOVA).

**RESULTS:**

A high cumulative ITL in the previous two weeks (>4000 AU) induced a significant (p<0.05) increase in PL2D and HAcc during matches. Specifically, post-hoc analysis revealed that PL2D was significantly higher compared to medium cumulative ITL (3000-4000 AU) but not respect to low cumulative ITL (<3000 AU), while HAcc showed a significant increase compared to low ITL but not to medium ITL. Moreover, a high percentage variation of ITL (>30%) determined a significant decrease (p<0.05) in SPD, HSD, NOS, PL2D, while all these parameters were significantly lower compared to a moderate increase in ITL (0-30%) but not respect to lowering in ITL (<0%).

**CONCLUSION:**

A high amount of ITL (>4000 AU) in the previous two weeks before a match was the optimal condition to induce higher ETL outputs as evidenced by the increase in PL2D and HAcc. Differently, a high percentage variation of ITL (>30%), compared to a moderate variation (0-30%), produced impairments in HSD, NOS, PL2D, TAcc, TDec, HAcc, HDec. Therefore, it is important to monitor not only absolute ITL but also the weekly relative change in order to avoid an excessive increase in workload, state of fatigue, risk of injury and impairment in performance.

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**ANALYSIS OF PHYSICAL DEMANDS AND FATIGUE INDUCED BY DIFFERENT SMALL SIDED GAMES IN SOCCER**

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**INTRODUCTION:**

Player movement patterns (external loads) can be used in addition to tactical information and physiological responses (internal load) to characterize competitive match play (1). In this regard, it is important for coaches to understand the interplay of an athlete's internal and external training loads to monitor fatigue and optimize performance (2). Therefore, this study aimed to analyze the effect of different small-sided games (SSG) on fatigue in young soccer players.

**METHODS:**

Sixteen male soccer players (mean  $\pm$  standard deviation; age  $17.1 \pm 0.6$  years; height:  $177.5 \pm 6.1$  cm; body mass:  $64.2 \pm 8.0$  kg) participated in this study. Subjects played in the under-18 British Local League. The SSG formats were composed of 7 players a side with goalkeepers (i.e., 7 vs. 7 + 2 GK). The total duration for each SSG was 24 min, performed in the following formats: 3 x 8 min with large pitch (SSG8; 68 x 40 m) with 4 min of rest, 6 x 4 min with large pitch (SSG4; 68 x 40 m) with 2 min of rest, and 6 x 4 min with small pitch (ssg4; 40 x 34 m) with 2 min of rest. Time-motion characteristics were assessed by a Global Positioning System (GPS) with the next activity ranges (3): total distance covered (TD), low-intensity running (LIR; running speed  $<13.0$  km·h<sup>-1</sup>), high-intensity running (HIR; running speed from 13.1 to 16 km·h<sup>-1</sup>), very high-intensity running (VHIR; running speed from 16.1 to 19 km·h<sup>-1</sup>) and sprinting distance (Sprinting; running speed  $>19.1$  km·h<sup>-1</sup>), besides recording the mean velocity (Vmean) and maximal velocity (Vmax) achieved (4). Number of accelerations (Acc) and decelerations (Dec) were collected above 2 m.s<sup>2</sup> (5). Pre- and post-training physical performance was measured as follows: countermovement jump (CMJ), kick velocity (KV) and 20 m sprint (T10, T10-20 and T20). CMJ was also evaluated at 8 and 16 min of each SSG.

**RESULTS:**

It was observed significantly lower TD, HIR, VHIR, Sprinting, Vmean and Vmax during ssg4 compared to SSG8 and SSG4. Furthermore, higher VHIR and Dec values were observed for SSG4 compared to SSG8 and ssg4, respectively. No significant differences were found for CMJ and KV between SSGs and neither intra SSGs. T10 values were significantly slower after SSG4 compared to SSG8. Lastly, all SSGs induced a significant decrease in T20 performance at Post.

**CONCLUSION:**

These findings suggest that relative area is the main variable for getting higher values of distance and velocity. Moreover, SSGs of 4 min bouts are more stressful for the acceleration phase of sprint than longer duration.

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**OMNI SCALE OF PERCEIVED EXERTION: SELF-REGULATION OF EXERCISE INTENSITY AMONG FEMALE SOCCER PLAYERS**

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**INTRODUCTION:**

Self-regulation of exercise intensity is important for soccer players. Optimal exercise intensity is necessary to improve cardiovascular and peripheral adaptations, and may reduce injuries. The purpose of the study was to investigate if adult female soccer players can self-regulate their exercise intensity corresponding to the ventilatory breakpoint (Vpt) during a field soccer session using an adult OMNI Rating of Perceived Exertion scale (RPE).

**METHODS:**

10 female adults participated in this study (age:  $23.30 \pm 1.49$  years, height:  $161.10 \pm 7.50$  cm, body fat:  $22.20 \pm 3.90$  per cent, body weight:  $49.01 \pm 3.90$  kg). Participants completed a perceptual estimation submaximal treadmill test to determine their Vpt, followed by self-regulation of exercise intensity during the 2 field soccer sessions (S1 and S2) utilizing the RPE scale.

**RESULTS:**

The Vpt was established at a RPE  $4.89 \pm 0.93$ . During the two 30-minute S1 and S2 conducted on different days, the females were able to achieve a RPE intensity of 4 to 6 which corresponded to the Vpt obtained during the treadmill testing. There was no significant difference between HR during S1 and S2 and HR of the treadmill testing for Vpt (HR S1 and S2:  $161.94 \pm 12.80$  bpm vs HR Vpt at treadmill:  $156.06 \pm 12.25$  bpm,  $p = 0.10$ ). RPE was also not significant (RPE S1 and S2:  $5.0 \pm 0.50$  vs RPE Vpt at treadmill:  $4.89 \pm 0.93$ ,  $p = 0.76$ ). There was also no significant difference between RPE and HR for both S1 and S2 (Warm up of 10 minutes: HR S1:  $129 \pm 11.2$  bpm vs HR S2:  $125 \pm 7.40$  bpm; RPE S1:  $2.30 \pm 0.68$  vs RPE S2:  $2.30 \pm 0.57$ ), Main body of the activity of 30 minutes: HR S1:  $162.50 \pm 14.69$  bpm vs HR S2:  $163.70 \pm 8.92$  bpm; RPE S1:  $4.90 \pm 0.99$  vs RPE S2:  $5.00 \pm 0.47$ ; Cool down of 10 minutes: HR S1:  $108.10 \pm 17.98$  bpm vs HR S2:  $108.20 \pm 11.56$  bpm, RPE S1:  $1.40 \pm 0.52$  vs RPE S2:  $1.50 \pm 0.52$ , ( $p > 0.05$ ). In addition, the RPE and HR results were significantly different between the warm up, main body of the activity (RPE:  $2.2 \pm 0.79$  vs  $5.0 \pm 0.47$ ,  $p = 0.00$ ; HR:  $132.30 \pm 7.89$  bpm vs  $167.00 \pm 2.05$  bpm,  $p = 0.00$ ), main body of the activity and cool down (RPE:  $5.0 \pm 0.47$  vs  $1.7 \pm 0.48$ ,  $p = 0.00$ ; HR:  $106.40 \pm 7.03$  bpm vs  $167.00 \pm 2.05$  bpm,  $p = 0.00$ ) during the soccer sessions. This indicated that the female soccer players were able to exhibit intensity discrimination.

**CONCLUSION:**

The current results indicated that adult female soccer players were able to self-regulate their exercise intensity at Vpt corresponding to a RPE 4 to 6 during field soccer sessions. This self-regulation enables female soccer players to train at optimal exercise intensities that may be able to increase cardiovascular and peripheral adaptations and may reduce the risk of injuries.

**CP-AP08 Individual sports****PRESENCE OF A LONG-RANGE CORRELATION IN WORLD-CLASS TENNIS PLAYERS BY MEANS OF DISTANCE**

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**INTRODUCTION:**

In a tennis match, two players continue dynamic interaction process through a tennis ball [1,2]. One of the elemental strategies is to send the tennis ball further from an opponent to break down the balanced interaction or to force opponent to leave the area near the center mark whereas an opponent tries to maintain. The aim of this study was to analyze the movement patterns of highly skilled players in terms of a long-range correlation between winner and loser in a competitive match. We hypothesized the winner of the match will show shorter distances from the center mark and a long-range correlation will be detected for winner in the distance time series as self-affinity as winner stays close to the center mark.

**METHODS:**

2013 Australian Open 1st Round (Federer vs. Paire) was selected, and every frame with tennis ball displacements ( $n = 684$  frames) was captured from a high definition video of the match (25 fps from 720p) for analysis. Time series was generated after excluding frames with serves and outs. The positions of the two players and the displacements of the tennis ball on the court were used for distance time series. Both distances between the player and tennis ball (PTB), and between the player and the center mark (PCM) were calculated. Detrended fluctuation analysis (DFA) was applied to observe a long-range correlation between winner and loser [3].

**RESULTS:**



Winner in the 1st round showed approximately 50 cm shorter distance in average between tennis ball and player ( $465.83 \pm 219.07$ ), and 10 cm shorter between center mark and player ( $288.16 \pm 174.49$ ) when compared with loser ( $517.11 \pm 247.32$  and  $296.08 \pm 200.31$  respectively) in average. DFA results showed that winner showed a long-range correlation on PCM ( $\alpha_1 = 0.50$ ,  $\alpha_2 = 0.53$ ), whereas loser showed random correlation and unstable displacements on PTB and PCM ( $\alpha_1 = 0.48$ ,  $\alpha_2 = 0.47$ ).

**CONCLUSION:**

The results support that the winner stayed closer to the center mark as well as tried to maintain distances from the player to the tennis ball. The distance time series can be a good performance indicator to differentiate a winner from a loser.

**FEASIBILITY OF A SHORTER FUNCTIONAL THRESHOLD POWER TEST IN CYCLING: A PILOT STUDY**

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**INTRODUCTION:**

Power meters provide the calculate and option to monitor power output (PO) in real-time leading an increasing number of cyclists to use these devices. Widely adopted in the laboratory and in the field, are the Critical Power (CP) and the Functional Threshold Power (FTP) tests, which both estimate the metabolic quasi-steady state of the athletes. Because in the world of elite sport, saving time for tests is essential, the present study aimed to evaluate the feasibility of shorter FTP protocols and to compare, directly in the field, FTP and CP.

**METHODS:**

Nine male elite cyclists (mean (SD). Age: 38.9 years (12.1); height 170 cm (0); weight 66.2 kg (8.2)) performed three tests in the field using their road bike which was equipped with a PowerTap Elite power meter (CycleOps, Madison, USA) which was connected to a Garmin Edge 500. Participants performed three protocols in randomised order with 24 hours rest between each test together with the same standardised warm-up for each. The protocols were the CP12 in which athletes performed 3 maximal effort trials (TT) over 12, 5 and 3 min (1); the CP20 in which athletes performed 3 TT over 20, 12 and 3 min; and the conventional FTP test (3). The agreement between the different test protocols for CP20 (W), CP12 (W), FTP (W), three novel single tests over 12 min (NT12; W), 5 min (NT5; W) and test 3 min (NT3; W) was assessed using the ANOVA test for one-way repeated measurements followed by a post-hoc Turkey test. The Bland-Altman test was used to establish the differences between the means. Statistical significance was accepted with a  $p < 0.05$ .

**RESULTS:**

All data were normally distributed. There were no statistical differences between CP12 and CP20 ( $p = 0.9993$ ), and FTP ( $p = 0.9342$ ) and NT12 ( $p = 0.9929$ ). While CP12 was significantly different from the NT5 ( $p = 0.0011$ ) and NT 3 ( $p = 0.0005$ ). Results were confirmed by the Bland-Altman test with the averages of CP12 and FTP (95% Limits of Agreement (LoA):  $-44 +32$  W), of CP12 and CP20 (95% LoA:  $-42 + 38$  W), of CP12 and NT12 (95% LoA:  $-38.94; +32.94$ ) were equivalent.

**CONCLUSION:**

The results presented above demonstrate that FTP can be evaluated with a 12-min instead of a 20-min protocol. Also, CP12, CP20, and FTP are tests that are equivalent to the assessment of aerobic performance in cycling. However, a larger sample size is recommended to confirm the present results.

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**THE SOURCE OF PROPULSION IN VARIOUS CLASSIC AND SKATING CROSS-COUNTRY SKIING TECHNIQUES IN WORLD-CLASS SKIERS**

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**INTRODUCTION:**

Cross-country skiing (XCS) is unique with respect to the diversity of sub-techniques employed. The two basic skiing techniques, classical and skating, include up to five sub-techniques, excluding curved and downhill sections. These techniques are chosen based on speed, track topography, snow-conditions and XCS skiers skills. The single techniques use both the upper (UB) and lower body (LB) to various extents to overcome air drag, gravity and friction in a bi-, tri- or quadrupedal mode. While some studies have investigated the force contributions from UB and LB in single techniques (1-4), there are discrepancies in the results. Further, a holistic analysis across a broad range of XCS techniques in elite XC skiers is lacking. Therefore, the aims of this study were to: a) develop a XCS push-off model applicable across all XCS sub-techniques, and b) determine the contribution of UB and LB to propulsion within these techniques.

**METHODS:**

Seven world-class male XC skiers completed seven incremental peak speed roller skiing tests on a treadmill (3) [double poling (DP) flat (1.5°), DP up (7°), V2 flat (2.5°), V2 up (7°), diagonal stride up (7°), V2 alternate flat (2.5°), V1 up (7°)]. Pole and plantar forces and 3D whole-body kinematics (including poles and roller skis) were analyzed at the highest absolute treadmill speed all skiers were able to complete. The modified push-off model described by (3, 5) was further adapted to fit all analyzed sub-techniques and used to calculate force components of UB and LB propulsion. Repeated measures ANOVAs for mean propulsive cycle force of legs & poles across all sub-techniques were applied.

**RESULTS:**

Besides 100% UB contribution to propulsion in the two DP situations, the highest UB contribution was achieved by V2 up and V2 flat ( $66.6 \pm 1.6\%$ ,  $59.7 \pm 1.8\%$ ,  $P = 0.052$ ) both being higher ( $P < 0.001$ ) compared with V1, V2 alternate ( $45.6 \pm 1.9\%$ ,  $43.1 \pm 2.4\%$ ,  $P = 0.41$ ) and diagonal stride ( $19.5 \pm 1.7\%$ ).

**CONCLUSION:**

For the first time, the UB and LB contribution across a broad range of XCS techniques in elite skiers is presented. For the skating techniques it was clearly shown that highest propulsive contribution from UB is generated in the V2 technique (60-67%), while LB contributes to a greater extent in both the V1 and V2 alternate techniques (~55%). UB contribution for V1 skating in our skiers was lower compared to equal distribution observed in (1) and 66% in the study of (2). Therefore, to unload the LB in uphill terrain, skiers should utilize V2 rather than V1, while for flat terrain V2 instead of V2 alternate is advised, and vice versa. However, a greater use of the V2 technique is related to a high UB capacity. For the classical style, the current study supports findings of previous work (4), that within the diagonal stride pole forces may serve other purposes besides the generation of propulsive forces.

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**THE SYSTEM BOARD: AN EFFECTIVE TRAINING TOOL IN INDOOR BOULDERING?**

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GERMAN SPORT UNIVERSITY COLOGNE

## INTRODUCTION:

System boards are compact bouldering walls outfitted with climbing holds that are set in a standardized, symmetrical pattern to guarantee a simultaneous workout of both body sides. The purpose of the present study was to investigate the use of a 60-degree-overhanging, 3.5-meter-high, and 2.5-meter-wide system board (T-Wall) to increase (a) finger and (b) upper body strength, (c) local endurance, and (d) bouldering ability level.

## METHODS:

Thirty-one experienced male athletes ( $29.9 \pm 5$  yrs;  $1.73 \pm 0.8$  m;  $64.7 \pm 5$  kg;  $7.7 \pm 4$  yrs bouldering experience) participated in a 4-week system board regimen (three sessions per week, each of a 120 min duration), using the ticklist-method, in which participants attempted a maximum number of bouldering problems. Data collection (pre-test, post-test after 48 hrs, and post-test after one week) included body weight (BW), self-perceived activation (PA) and training state (PT), handheld grip strength dynamometry (GS), lactic acid analysis (LAC) post-intermittent fingerboard hangs to exhaustion (IFH), the total number of pull-ups (PU) and successful bouldering ascents (BA), room temperature (T), and humidity (H). All subjects provided written informed consent, and the study protocol received ethical approval from the University.

## RESULTS:

Multivariate analysis of covariance (MANCOVA) indicated significant increases in PU ( $8 \pm 3$  RM;  $12 \pm 2$  RM;  $12 \pm 2$  RM;  $p = .037$ ) and IFH ( $15 \pm 3$  RM;  $27 \pm 11$  RM;  $27 \pm 10$  RM;  $p = .011$ ) with non-significant ( $p = .780$ ) results for the LAC ( $3.4 \pm 1$  mmol;  $4.2 \pm 1$  mmol;  $4.0 \pm 1$  mmol). BA ( $3.5 \pm 0.5$ ;  $4.4 \pm 0.3$ ;  $4.3 \pm 0.3$ ) and PT ( $3.7 \pm 1$ ;  $5.3 \pm 3$ ;  $9.5 \pm 2$ ) were significantly ( $p = .003$ ;  $p = .032$ ) greater after the four-week regimen, whereas a non-significant gain ( $p = .278$ ) was found in GS ( $449.7 \pm 92$  N,  $511.6 \pm 49$  N,  $509.5 \pm 5$  N). Non-significant results in BW, PA, T, and H ( $p > .05$ ) suggest standardized test implementation.

## CONCLUSION:

Our findings suggest that system boards are highly effective for increasing sport-specific upper body strength and local endurance. The observed gains could mainly be related to the steepness of the board and the strenuous bouldering problems that were worked maximally to the point of muscular failure. Moreover, significant increases in BA and PT emphasize the sport-specific functionality of system board regimens, whereas the non-significant GS findings could be attributed to the grip types and sizes.

**ISOKINETIC PROFILE OF SHOULDER ROTATIONAL STRENGTH IN ELITE JUNIOR TENNIS PLAYERS – IMPACT ON SERVE VELOCITY**

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## INTRODUCTION:

The modern game of tennis is presently characterized by strength, speed, and power with higher stroke and serve velocities, that require a notably higher level of strength and physical fitness. To develop an isokinetic profile of tennis players' shoulder strength can be useful not only for the enhancement of performance but also in the prevention of injury. Therefore, the aim of this investigation was to evaluate shoulder rotational strength (internal and external rotation) and the influence on serve performance.

## METHODS:

Twelve elite junior tennis players ( $14.4 \pm 1.6$  yrs,  $176.7 \pm 14.0$  cm,  $61.3 \pm 14.7$  kg) participated in this investigation. Each subject was tested isokinetically with the IsoMed2000 in a seated position with stabilization straps secured at the pelvis and midthoracic levels. Tests were performed with the shoulder in 90 deg of abduction and the elbow was maintained in 90 deg of flexion. After a standardised warm up and familiarization, five maximum repetitions of internal and external rotation were performed at 60 and 180 deg/s. Subjects were randomly assigned to begin testing with either the dominant (D) or nondominant (ND) arm. For measuring serve velocity (Stalker Professional Sports Radar) subjects performed 8 maximum flat serves from the deuce service side.

## RESULTS:

Shoulder internal rotational peak torque at both low and high test speeds were significantly higher on the serving than non-serving side (60 deg/s:  $38.2 \pm 10.0$  Nm vs.  $30.4 \pm 7.5$  Nm,  $d = 0.84$ ,  $p = 0.00$ ; 180 deg/s:  $39.6 \pm 12.0$  Nm vs.  $30.5 \pm 8.8$  Nm,  $d = 0.81$ ,  $p = 0.00$ ). No significant difference between extremities were identified in external rotation ( $p > 0.05$ ). Regarding the external/internal (ER/IR) ratio there were lower ratios on the dominant arm as compared to the non-dominant side (60 deg/s:  $71.4 \pm 12.3$  % vs.  $79.5 \pm 14.6$  %,  $d = 0.60$ ,  $p = 0.04$ ; 180 deg/s:  $66.5 \pm 12.4$  % vs.  $75.6 \pm 14.4$  %,  $d = 0.68$ ,  $p = 0.07$ ). Partial correlation analysis indicated significant high relations between internal rotation strength on the dominant arm and serve velocity (60 deg/s:  $r = 0.81$ ; 180 deg/s:  $r = 0.70$ ).

## CONCLUSION:

The data of this investigation indicate that tennis causes adaptive strength changes in the players' dominant arm. This unilateral increase without matched development in external rotation strength leads to a lower ER/IR ratio on the serving arm. Further, high internal rotational strength seems to be a good predictor of service speed and should be focused in training programs. Despite the importance of internal rotational strength for tennis performance, strength training should be implemented which includes both internal and external rotation to prevent muscular imbalances and thus minimize the risk of injury.

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## EFFECT OF REPEATED JUDO MATCHES ON MAXIMAL HANDGRIP FORCE AND BLOOD ACID-BASE REGULATION IN FEMALE WORLD-CLASS JUDOKAS

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### INTRODUCTION:

A judo match is characterized by repeated high-intensity efforts with varying durations from a few seconds (e.g., quickly ippon) to four minutes (official time) or more (i.e., golden score). This kind of activity is metabolically stressful since high post-match blood lactate concentrations were associated with large losses of maximal isometric handgrip force in male judokas of regional and national levels (Bonitch-Gongora et al., 2012). However, this remains to be proven in world-class judokas. Thus, the aim of this work was to study the time course of maximal isometric handgrip force and blood acid-base balance during repeated matches in world-class judokas.

### METHODS:

Seven female world-class judokas (age:  $24.1 \pm 3.0$  years) repeated four 4-min judo matches separated by 15 min of passive recovery. Six of them had previously won a world medal (Olympic games or World championships). Maximal voluntary isometric contraction (MVIC) force of finger flexors was measured immediately after each match using a handgrip dynamometer. Judokas were standing with the elbow joint flexed at  $90^\circ$  and the hand in neutral position. MVIC force of both hands was tested and classified as MVIC hikite force (pulling hand) or MVIC tsurite force (lifting hand). Capillary blood pH, bicarbonate ( $[\text{HCO}_3^-]$ ) and lactate ( $[\text{La}]$ ) concentrations were measured within 5-10 min after each match.

### RESULTS:

MVIC hikite force significantly decreased over the four matches compared to initial value (PRE:  $492 \pm 114$  N vs. POST 1:  $447 \pm 71$  N, POST 2:  $440 \pm 76$  N, POST 3:  $419 \pm 92$  N and POST 4:  $430 \pm 74$  N;  $P < 0.05$  at least) while MVIC tsurite force only significantly declined from the match 3 (PRE:  $459 \pm 84$  N vs. POST 3:  $422 \pm 67$  N and POST 4:  $419 \pm 76$  N;  $P < 0.05$  at least). Moreover,  $[\text{La}]$  significantly increased up to  $12.95 \pm 2.1$  mmol·L<sup>-1</sup> ( $P < 0.001$ ) while blood pH only decreased by 0.2 units after the last match (PRE:  $7.44 \pm 0.03$  vs. POST 4:  $7.25 \pm 0.04$ ;  $P < 0.001$ ). The moderate decrease in blood pH was associated with a significant decrement in  $[\text{HCO}_3^-]$  (PRE:  $19.99 \pm 2.01$  mmol·L<sup>-1</sup> vs. POST 4:  $10.48 \pm 1.49$  mmol·L<sup>-1</sup>;  $P < 0.05$ ).

### CONCLUSION:

The results show in female world-class judo athletes that the pulling hand (hikite) fatigues faster than the lifting hand (tsurite) during repeated high-intensity matches. This could be ascribed to the more fatiguing action of pulling on the sleeve during matches. However, mean loss of force was moderate (MVIC hikite force: -12.6%, MVIC tsurite force: -8.7%) despite the highly stressful side of matches ( $[\text{La}]$ : 12.95 mmol·L<sup>-1</sup>). In addition, the regulation of blood acid-base balance was efficient in judokas, as evidenced by the low decrement in blood pH. This is explained by the high buffering capacity of H<sup>+</sup> ions by bicarbonates (i.e., high  $[\text{HCO}_3^-]$  reduction). Taken together, these results indicate that female world-class judokas have high abilities to resist to fatigue and regulate their blood acid-base balance during repeated high-level matches.

## CHANGES IN CORTISOL AWAKENING RESPONSE AND HEART RATE VARIABILITY AFTER SHORT-TERM INTENSIFIED TRAINING IN COLLEGIATE JUDO ATHLETES.

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### INTRODUCTION:

The cortisol awakening response (CAR) has been used as a non-invasive biomarker of stress response in many psychological investigations. Recently, it has been reported by several studies that the CAR can be a capable index for monitoring stress response induced by exercise training load in multiple sports events. However, the number of studies concerning the CAR in exercise is still limited. Especially, there is no investigation which compare the CAR and other physiological parameters, such as, heart rate variability (HRV), total fatigue score (TFS) for estimating training oriented fatigue, and visual analogue scale for general fatigue (VASF) at the same training period. The aim of this study was to examine changes of CAR, HRV, TFS, and VASF in short-term intensified training in collegiate judo athletes.

### METHODS:

Twenty collegiate judo athletes volunteered for the study. The athletes completed HRV recording, fitness test, and saliva collections for measuring CAR, before (pre) and after (post) six days intensified training. The subjects completed a 10-min warm-up consisting of light aerobic activity and lower body static stretches before a fitness test; counter movement jump (CMJ), hand grip strength, and single-leg 4 direction hopping (S4DH). For the CAR measurement, all subjects performed the first saliva sampling immediately after awakening, and further samples were collected at 15 and 30 min thereafter. TFS and a VASF were measured at the end of each training day. Paired t-test was performed to compare pre and post difference of each parameter, and two-way repeated measures ANOVA was performed to detect differences in CAR between pre and post training. A statistical level of  $p < 0.05$  was accepted. All data are expressed as mean  $\pm$  SEM.

### RESULTS:

Body weight and all parameters of the fitness test (CMJ, grip strength, and S4DH) were significantly decreased after intensified training. These results suggested that the intensified training caused overreaching in judo athletes. Resting heart rate was significantly increased after intensified training ( $58.8 \pm 6.7$  to  $69.6 \pm 12.2$  bpm,  $P < 0.01$ ). Post training RMSSD ( $71.6 \pm 37.4$  to  $39.1 \pm 19.3$  s,  $P < 0.05$ ) and HF n.u. ( $46.3 \pm 21.9$  to  $25.0 \pm 9.7$ ,  $P < 0.01$ ) showed significant decrease, LF/HF ratio ( $1.7 \pm 1.3$  to  $3.9 \pm 2.6$ ,  $P < 0.01$ ) showed significant increase compared to pre training. These results indicated that subjects showed typical acute exhaustion condition after intensified training. Moreover, peak cortisol concentration of CAR (CARpeak) significantly increased after training ( $15.54 \pm 4.97$  to  $20.41 \pm 9.11$  nmol/l,  $P < 0.05$ ). CARpeak showed strong significant correlations with LF ( $r = 0.699$ ,  $P < 0.01$ ), CMJ ( $r = -0.578$ ,  $P < 0.05$ ), and VASF ( $r = 0.727$ ,  $P < 0.05$ ). TFS had no significant correlation with CARpeak and HRV parameters.

### CONCLUSION:

These findings suggest that the CAR is one of the available indices which reflect overreaching/exhaustion and general fatigue status induced by short-term intensified training in Judo athletes. Supported by Grant in Aid for Young Scientist B.

**EFFECTS OF SINGLE BOUT OF 20 MIN ROWING EXERCISE WITH WB-EMS ON CREATINE KINASE AND LACTATE BLOOD LEVELS, HEART RATE, BLOOD OXYGEN SATURATION AND HEART RATE VARIABILITY**

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**INTRODUCTION:**

Electro stimulation involves the direct application of electrical impulses to muscle tissue and has been used to prevent muscle atrophy and promote muscle strength. Whole body electrostimulation (WB-EMS) is a novel variant of EMS that involves the application of impulses to both the torso and extremities. The aim of this study was to investigate the effects of the application of WB-EMS on healthy and physically active young people undergoing intense exercise on muscle damage, cardiovascular system and autonomic modulation of nervous system.

**METHODS:**

Nineteen healthy and physically active subjects (ten men and nine women) participated in the study. Their age, body weight and height were  $25.6 \pm 5.0$  yo,  $68.7 \pm 11.1$  kg and  $1.68 \pm 0.7$  m. Each participant performed three separate experimental trials consisting of 20 minutes of rowing exercise on an ergometer. Randomly, participants performed 3 different protocols: exercise with WB-EMS using continuous stimulation (85 Hz, 250/350  $\mu$ s, CNT-WB-EMS), exercise with WB-EMS using coordinating the stimulation with the movement of the concentric phase of the muscle contraction (85 Hz, 250/350  $\mu$ s, CRD-WB-EMS), and exercise without WB-EMS (NO-WB-EMS). CK was measure pre, post and 24h post exercise. Lactate and HRV were measure pre and post exercise. HR and BOS were measure pre exercise, after 10' warm-up and at the end of the exercise trial.

**RESULTS:**

We found no difference CK blood levels. Lactate levels significantly increases with exercise with no differences between trials (mean  $1.8 \pm 0.9$  and  $9.0 \pm 3.7$  mmol/l pre and post exercise respectively;  $p < 0.05$ ). HR significantly increased from pre exercise to warm-up and to end of exercise, with no differences between trials (mean  $70.5 \pm 14.7$ ,  $122.3 \pm 25.1$  and  $162.4 \pm 19.7$  respectively;  $p < 0.05$ ). BOS did not significantly change in any trial. Finally, we did not find any significant change in HRV variables measured: RMSSD and LF-HF ratio.

**CONCLUSION:**

These outcomes showed that WB-EMS did not affect muscle damage, cardiovascular and autonomic modulation of nervous system different than intense exercise without WB-EMS application. Thus, WB-EMS seems to be safe and harmless during aerobic exercise when using in healthy and physically active young people.

**CP-AP09 Interval training****THE ANAEROBIC SQUAT TEST AS A VALID AND RELIABLE ALTERNATIVE TO MEASURE THE ANAEROBIC CAPACITY IN HIGH INTENSITY FUNCTIONAL TRAINING ATHLETES.**

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**INTRODUCTION:**

Different tests have been proposed to quantify the anaerobic capacity in trained individuals (Cular et al., 2018; Fry et al., 2014; Sands et al., 2004). However, most of them are difficult to apply due to the complexity or equipment/facilities requirement. The Anaerobic Squat Test (AST) is a 30 seconds maximal effort test where athletes had to perform as many squats as possible with a percentage of their body weight. The purpose of this study was to validate an affordable cost-economic tool in order to evaluate the anaerobic capacity in athletes.

**METHODS:**

Nineteen High Intensity Functional Training (HIFT) athletes were recruited (age  $28.3 \pm 6.62$  years; stature  $176.18 \pm 5.34$  cm; weight  $81.67 \pm 6.43$  kg) and tested on separate sessions with 48 hours of difference. They were advised to refrain from any high intensity physical activity the previous 24 hours of every test. Two different percentages of intensity were carried out: 60% (AST60) and 70% (AST70) as percentage of body weight. Power values were registered by accelerometry (Beast Sensor) and Wingate test as a reference. Reliability was assessed by intra-class correlation coefficients (ICC) and validity by Pearson correlation coefficients for peak (pp), mean (xp) and minimum (mp) power outputs compared with Wingate test (WG).

**RESULTS:**

Peak power values of AST60 and AST70 showed significant correlation with WG (AST60PP  $r = 0.51$ ,  $p < 0.05$  and AST70PP  $r = 0.55$ ,  $p < 0.05$ ). Regarding to mean power, only AST60 showed significant correlation with WG (AST60xp  $r = 0.49$ ,  $p < 0.05$ ). No statistically significant correlations were found in minimal power values. The ICCs of AST60 peak, mean and minimum power were 0.64 (95% CI: 0.22-0.86), 0.76 (95% CI: 0.45-0.91) and 0.71 (95% CI: 0.33-0.89), respectively. Values for AST70 were 0.61 (95% CI: 0.19-0.84), 0.67 (96% CI: 0.30-0.87) and 0.71 (95% CI: 0.35-0.88), respectively.

**CONCLUSION:**

In conclusion, our results suggest that the AST is a valid and reliable tool to measure the anaerobic capacity in HIFT athletes. Further prospective studies using higher intensity percentages (e.g., 75% or 80%) are needed in order to find more accurate agreement.

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**VARIABILITY OF ACUTE RESPONSE IN RESTING HEART RATE VARIABILITY FOLLOWING HIGH-INTENSITY INTERVAL TRAINING**

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**INTRODUCTION:**

Exercise intensity was described as a main determinant of acute changes in heart rate variability (HRV) following endurance-based exercise [1]. Yet, it remains unclear if (intensity-dependent) acute HRV patterns can be consistently observed in single athletes, due to a typically

large day-to-day variability. We therefore performed post hoc analyses on the replicability of acute HRV responses following high-intensity interval training (HIIT) during a 4-week training trial.

**METHODS:**

26 well-trained male intermittent sport athletes completed a 4-week HIIT training trial (3-week progressive loading, 1-week taper)[2]. Three HIIT sessions were scheduled per week with 2-, 3- or 4-min intervals at 100, 95 and 90% of  $\dot{V}O_{2peak}$  target running speed, respectively. We assessed daily supine heart rate (HR) and HRV (LnRMSSD) after awakening 2 weeks prior (baseline), during, and 2 weeks following the training period. HR and HRV changes from HIIT training day (pre) to the following day (post) were calculated and defined as acute exercise response. Responses were summarized as individual mean and standard deviation (SD) and compared to individual baseline variability (SD). Data were only considered for analysis if HIIT was performed after a day of recovery, and if at least 5 replications were available per athlete during the loading period.

**RESULTS:**

Seven athletes could be included for analysis ( $25 \pm 3$  years,  $\dot{V}O_{2peak}$   $55 \pm 5$  ml/kg/min, range: 5 to 9 replications). Mean acute exercise responses in HR +2.4 bpm (-0.5 to 6.3 bpm) and LnRMSSD -0.14 ms (-0.37 to 0.08 ms) were smaller than baseline variability (HR 3.8 bpm, LnRMSSD 0.26 ms) on average and in 5 of 7 and 6 of 7 athletes, respectively. In addition, mean response variability was larger than baseline variability for HR (4.7 bpm, 2.8 to 8.8 bpm) and LnRMSSD (0.33 ms, 0.12 to 0.69 ms) on average and in 5 of 7 and 6 of 7 athletes, respectively.

**CONCLUSION:**

Despite plausible changes in HR and HRV, data indicated a poor signal-to-noise ratio in our sample, where individual mean response represents the signal and baseline variability represents measurement noise. Furthermore, observed variability of training response was larger than baseline variability, which might be due to the non-similar exercise sessions, inter- or intra-individual response variability or due to random error. Considering the study design and the purely exploratory and descriptive analysis, future studies may use similar exercise protocols and especially a more robust analytical strategy to investigate the replicability of acute HRV response following HIIT. In conclusion, although the current literature indicates a substantial mean decrease in HRV after high-intensity exercise [1], our data suggest that practitioners may observe both increased and decreased HR and HRV after HIIT on the individual level in comparable training settings.

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**THE EFFECT OF LOW-LOAD HIGH-INTENSITY INTERMITTENT INTERVAL TRAINING ON WELL-TRAINED SPRINT RUNNERS**

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**INTRODUCTION:**

High-intensity intermittent training improves anaerobic and aerobic energy-supplying systems (Tabata et al., 1996). Also, low-load maximal pedaling training using a cycle ergometer has a significant positive correlation with sprint ability (Nakamaru et al., 2004). The present study aimed to clarify the effects of high-intensity intermittent training with low-load maximal pedaling on physical fitness characteristics and the sprint ability of male sprint runners.

**METHODS:**

Thirteen well-trained male collegiate sprint runners participated in this study. They were divided into a training group (n=7) and a control group (n=6). All participants performed specific running training 5 days a week for 6 weeks. In addition, the training group performed low-load high-intensity intermittent training once a day, 2 times per week, for 6 weeks. Training consisted of 7 repetitions of a maximal pedaling training set at 1.0 kp for 20 seconds with a 10 seconds rest. Physical fitness characteristics were evaluated from maximal oxygen uptake ( $\dot{V}O_{2max}$ ), power of the Wingate Test (average, peak, decline rate) and peak rotation speed. Sprint ability was evaluated from a 300 meter sprint time with the time split every 100 meters.

**RESULTS:**

$\dot{V}O_{2max}$  significantly increased from  $48.80 \pm 3.74$  (ml/kg-min) to  $53.63 \pm 5.16$  (ml/kg-min) in the training group, and from  $44.76 \pm 3.15$  (ml/kg-min) to  $51.77 \pm 3.74$  (ml/kg-min) in the control group ( $p < 0.01$ ). All power values of the Wingate Test (average, peak, decline rate), the peak rotation speed, 300 meter sprint running time, and the 0–100 m and 200–300 m split time did not change significantly in either group.

**CONCLUSION:**

The improvement of aerobic work ability was a result common to both groups. It was determined that the effect was not due to high-intensity training but to regular professional training. As shown in the power values of the Wingate test, there was no change in the 300 m running performance since the anaerobic working ability was not improved. These results suggest that low-load high-intensity intermittent training with maximal pedaling effort did not affect the physical fitness and sprint running performance of the male sprint runners.

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**EFFECT OF HIGH INTENSITY INTERVAL TRAINING ON RUNNING PERFORMANCE IN RUGBY PLAYERS**

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**INTRODUCTION:**

We have introduced HIIT (High Intensity Interval Training) into rugby players while keeping usual rugby trainings. We compared its effects on the sprint ability, muscle strength and endurance capacity with endurance training group. We also evaluated the level of improvement in high intensity running and sprinting ability during actual rugby games by using GPS measurements.

**METHODS:**

We selected players from 65 university rugby club members, excluding injured persons. They were randomly assigned to the high intensity interval training group (hereafter group H) or the endurance training group (hereafter group E) based on repeated sprint ability. Group H mainly focused on HIIT which was 8 sets of 20 seconds of nearly full sprint with a 10-second break at a frequency of 3 times/week for 5

weeks. Group E focused on endurance training, which was a 30-minute continuous run at 70 % intensity at a frequency of 3 times/week for 5 weeks. Both groups conducted usual rugby training with same content with HIIT or endurance training respectively. Performance of 40 m sprint, repeated sprint ability (RSA), and a 12-minute running, body composition, and the running properties during rugby game were evaluated before and after the 5 weeks training. In this analysis, the number of rugby game was 1 game in both before and after respectively.

**RESULTS:**

A significant interaction was observed in RSA, and a significant difference was observed before and after the training in both groups E and H. In fact, the effect on sprint ability was higher with HIIT than with endurance training. In the 12-minute run, a significant difference was observed only in the group E. For the 40 m sprint running ability, a significant difference was observed in both the E group and the H group before and after training.

**CONCLUSION:**

The positive effect observed in group E may due to the usual training effect of rugby training. No significant difference was found in the GPS analysis during rugby games. In this study, the number of games to be verified was relatively few and therefore it may be necessary to perform measurement in many games. The results show that there was a significant higher improvement in the repeated sprint ability in high intensity training. However, the in-game GPS analysis did not show the significant difference.

**MOTIVATING MUSIC INCREASES THE PERFORMANCE IN THE 30-15 INTERMITTENT FITNESS TEST IN BASKETBALL PLAYERS**

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**INTRODUCTION:**

Music has been previously suggested as a powerful strategy to improve sport performance, (Karageorghis & Terry, 1997), but it remains unknown its impact on preserving the capacity to repeat sprints and change direction under large fatigue, characteristic of basketball. Our study aims to analyze the impact of music on the 30-15 Intermittent Fitness Test (IFT), widely used in this sport (Jeličić et al., 2019), to further understand its influence on the capacity to sustain long-lasting and highly demanding metabolic fatigue.

**METHODS:**

Thirteen young developing male basketball players from Valencia Basket Club (14.85±0.68y; 1.889±0.05cm; 75.89±8.02kg), were invited to rank a list of 40 songs by means of the Brunel Music Rating Inventory 3 (BMRI3, Karageorghis & Priest, 2008). We set three sampling conditions with regard to music: Highly Motivating Music (HMM), Low Motivating Music (LMM); and a No Music (NM) condition. During three weeks, all the players performed once, randomized in every music condition, the 30-15 IFT. Heart rate (HR), Blood Lactate (BLa), Arterial oxygen saturation (SaO<sub>2</sub>), Perceived readiness (PRR) and the ratings of perceived exertion (RPE), jointly with the maximal running velocity (VIFT), were retained for further analysis.

**RESULTS:**

VIFT\_HMM was significantly higher ( $p < 0.01$ ) than VIFT\_LMM and VIFT\_NM (19.57±0.14; 18.84 ±0.14 and 18.53±0.28 km/h respectively), with no significant differences in any psychophysiological response, despite a bit lower mean lactate (HMM: 6.74±1.75; LMM: 7.21±1.58; NM: 7.27±2.06 mmol.L-1), and higher PRR (HMM: 3.03±0.66; LMM: 3.03±0.77; NM: 2.80±0.77 ua) for the HMM condition.

**CONCLUSION:**

Young players reached high performance under fatigue (i.e. VIFT). HMM improved performance in this physiological context largely conditioned by maximal aerobic power, high anaerobic capacities, agility, and optimal recovery skills, all of them determinants of Basketball. The Synchronization between music and the motor tasks allowing the activity to be more efficient (Nikol et al, 2018) could underpin this higher performance for similar physiological exertion. The distracting effect of motivating music (Hutchinson & Karageorghis, 2013) could also help, confirming that music in an important training resource also in long-lasting and extenuating efforts.

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**EFFECTS OF ACUTE SUPRAMAXIMAL INTERMITTENT TRAINING AT MODERATE ALTITUDE ON ANAEROBIC CAPACITY**

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**INTRODUCTION:**

Previous studies reported that short-term training in hypoxia was used to enhance anaerobic performance [1]. However, the effects of acute anaerobic training at moderate altitude are unclear. The present study was conducted to determine whether acute supramaximal intermittent training at an altitude of 1450 m could alter anaerobic capacity.

**METHODS:**

Nine healthy men (age 22.3±2.1 y, height 173.1±5.0 cm, weight 69.7±5.3 kg, VO<sub>2</sub>max 50.2±7.2 ml/kg/min) underwent acute supramaximal intermittent training ( 120% VO<sub>2</sub>max, 120 rpm, 5×60 s) on a cycle ergometer with a 15 min rest between exercise under sea level (SL) conditions and at an altitude of 1450 m (MA). The 30 s Wingate Anaerobic Test (WAnT) was performed to determine the anaerobic capacity under sea level on the next day and 3 days after the training period. In addition, maximum cycling exercise test and WAnT (Baseline) were performed in advance. Arterial oxygen saturation (SpO<sub>2</sub>), local oxygen saturation (SmO<sub>2</sub>), oxygen uptake, blood lactate concentrations (BLa), rating of perceived exertion (RPE), peak power (Ppeak), mean power (Pmean), and fatigue index (FI; % of decrease in power output throughout the 30 s) were measured.

**RESULTS:**

The average values of SpO<sub>2</sub> and SmO<sub>2</sub> during the training sessions were significantly lower at MA than those at SL ( $P < 0.01/0.05$ ). In addition, Pmean, oxygen debt, and BLa at MA after WAnT performed 3 days after the training period were significantly higher than those at baseline ( $P < 0.05$ ). Further, FI was significantly lower at MA 3 days after the training period than that at baseline and the day after SL ( $P < 0.05$ ). Ppeak and RPE showed no significant change. Moreover, significant correlations were seen among the changes in SpO<sub>2</sub> from rest at SL to post training at 1450 m and that in Pmean seen on WAnT ( $r = 0.747, P < 0.05$ ).

CONCLUSION:

These results suggested that acute supramaximal intermittent training at an altitude of 1450 m improved the anaerobic capacity. It is believed that decreasing of SpO<sub>2</sub> level during supramaximal intermittent training in moderate altitude make anaerobic performance improve.

Reference:

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**EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING ON SKELETAL MUSCLE MASS AND IL-6 SERUM LEVELS IN YOUNG AND OLDER PEOPLE**

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INTRODUCTION:

Aging is accompanied by a progressive decrease of skeletal muscle mass and strength, with detrimental effects on functional capacity – a condition called sarcopenia. Multiple factors have been related to the etiology of sarcopenia, such as the increased production of IL-6. However, the influence of high-intensity interval training (HIIT) on IL-6 serum levels and skeletal muscle mass in the elderly has not yet been studied. Therefore, the aim of this study was to determine differences between the changes of skeletal muscle mass/functional capacity and IL-6 serum levels on young vs older people after 12 weeks of HIIT.

METHODS:

Healthy young (YNG, 21±1 y, BMI 26.37±2.69 n=12) and older (OLD, 67±5 y, BMI 27.22±3.04 n=12) males were subjected to 12 weeks of HIIT in a cycle ergometer. Two days prior to and immediately after the HIIT program, Dual-energy X-ray absorptiometry (DXA), single leg one-Repetition Maximum (1RM) strength tests, VO<sub>2</sub>max, unipodal stance and timed up and go (TUG) tests were performed to assess whole-body and leg fat and lean mass, leg muscle strength, aerobic capacity and physical performance, respectively. Furthermore, blood samples were taken to assess biochemical profile, insulin and IL-6 levels. A two-factor (age x training) repeated-measures ANOVA was performed for the analysis of the variables. Independent and Paired samples t-tests were used when necessary to determine differences between groups (YNG vs OLD) and training (PRE vs POST). Pearson test was used to determine correlation between IL-6 and other variables. Data is presented as mean ± SD.

RESULTS:

Unipodal stance test, 1RM dominant leg strength, dynamic equilibrium (TUG), VO<sub>2</sub>max were higher in YNG vs OLD (P<0.05). The HIIT improved the 1RM dominant leg strength (P=0.025), VO<sub>2</sub>max (P<0.001), legs lean mass (P=0.047), blood glucose (P=0.006) and cholesterol (P=0.017). TUG was improved by the training only in the OLD group (P=0.016), but insulin (P=0.002) and the HOMA-index (P<0.001) decreased only in the YNG group. While no differences were observed in IL-6 serum levels, there was a modest correlation between IL-6 and whole-body lean mass (r = 0.56, 95% CI = 0.11 to 0.79, P = 0.017) in the YNG group only.

CONCLUSION:

After 12-week of HIIT we observed an increase in skeletal muscle mass, strength and aerobic capacity in older people, which translated to an improvement in functional capacity, including dynamic equilibrium (TUG). Those changes were accompanied by a decrease in serum glucose and cholesterol, but no changes in serum IL-6, which was not correlated with any of the improvements observed in the OLD group. Supported by FONDECYT - Chile (Grant Number 11180949) and Dirección de Investigación (DIUFRO) of Universidad de La Frontera (Grant Number DI18-0068). Contact: gabriel.marzuca@ufrontera.cl

**THE EFFECTS OF DIFFERENT DURATION OF TOTAL WORK ON PHYSICAL FITNESS IN HIGH INTENSITY INTERVAL TRAINING USING TABATA.**

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INTRODUCTION:

: High-intensity interval training (HIIT) is a time-efficient strategy shown to improve aerobic and anaerobic power and capacity. In most individuals, HIIT used in activities such as cycling, rowing and running typically results in increased aerobic capacity only. However, little is known about the HIIT volume necessary for building muscle strength, especially using body weight. The purpose of this study is to investigate the different training duration effects of an eight-week high-intensity interval training period on physical fitness.

METHODS:

42 male college students were randomly assigned to three different groups: high-volume, low-volume HIIT (HT, LT) and the control group (CG). Low-volume HIIT (LT) conducted 2-4 sets of Tabata training. High-volume HIIT (HT) conducted two more sets of Tabata training than low-volume HIIT (LT) to measure the difference between training sets. The number of training sets was increased by 1 set on the 3rd and 7th week for maintaining intensity. The 1st set of Tabata training was a 4-minute set which was divided into 8 repetitions of 20-second intervals with a 10-second resting time in between. The training for both groups was performed 3 times a week for 8 weeks. The training consisted of body weight training that using the whole body, core and a series of jumping exercises. Body composition, maximal oxygen consumption (VO<sub>2</sub>max), isokinetic strength, 1-repetition maximum (1RM), flexibility, heart rate, and energy expenditure of all subjects were measured before and after the training program.

RESULTS:

Lean body mass (1.26kg difference, P=.001) improved for both training groups (LT & HT) compared to control group (CG). As expected, body weight (-1.25kg difference, P=.029) is decreased in both groups. High-volume HIIT (HT) showed significantly positive effect on body fat percentage (-1.11% difference, P=.011) and maximal oxygen consumption (2.88 ml/kg/min difference, P=.001) than the low-volume HIIT (LT). It was proven that there was a significant difference between high-volume HIIT (HT) and low-volume HIIT (LT) according to isokinetic strength and 1-repetition maximum (1RM) bench press (2.06kg difference, P=.021) and flexibility (2.61cm difference, P=.004).

CONCLUSION:

Many types of traditional HIIT are time-efficient protocols leading to aerobic and anaerobic performance benefits, but they usually fail to make adaptations in muscle strength and performance. Our HIIT using body weight has the additional benefit of improving muscle strength

and performance in college men. Also, high-volume HIIT (HT) resulted in greater muscle performance increases than low-volume HIIT (LT). Future studies should examine the physiological adaptations achieved with combining HIIT with strength training and the effects of HIIT in females and older adults or those with chronic conditions.

## CP-AP10 Training and testing IV

### BIKE FITTING: A NONLINEAR APPROACH.

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#### INTRODUCTION:

In recent years, the study of human movement variability seems to be acquiring a new value, based on an approach deriving from the theories of dynamic systems and through the use of nonlinear analysis tools, it seems that it can provide additional information compared to traditional approaches. The calculation of the largest Lyapunov exponent (LyE) allows defining the degree of stability and predictability of a system. In the analysis of human movement, it was used in gait and postural control research. In particular, some research on amputee subjects (Wurdeman et al., 2013) proposed that LyE could represent how much two systems work together to carry out a given movement. From these assumptions, the idea behind this study was born, to apply these concepts to the man-bicycle system. Therefore the aim of this study is to verify if there is a correlation between the cyclists degree of preference, saddle height and LyE with 4 different setups.

#### METHODS:

An amateur cyclist has pedalled for 6 (x 3 trials) on a spin bike with 4 different saddle positions. A 6-camera optoelectronic system with a sampling frequency of 140Hz and a marker set of 12 reflective markers were used to obtain the kinematic data relating to the lower limbs. Hip, knee and ankle extension flexion angles were calculated. LyE was calculated on these kinematic parameters on a fixed number of 40,000 samples. The subject was asked to express a preference over 4 setups, on a scale of values ranging from minimum preference and maximum preference. The values of the preference parameter have been correlated with LyE. Furthermore, the correlation between LyE values and saddle height was computed. An ANOVA was performed on the data.

#### RESULTS:

There are no strong correlations between the degree of preference and LyE, except for the right hip ( $r = -0.89$ ) and the right knee ( $r = -0.72$ ). There is a good correlation between saddle height and LyE in the left hip ( $r = -0.92$ ), right knee ( $r = 0.70$ ), left knee ( $r = 0.75$ ) and right ankle ( $r = -0.84$ ). From ANOVA there are no significant differences except for the right ankle.

#### CONCLUSION:

LyE does not seem able to determine the riders preferred position, however, there is a relationship between saddle height and LyE. This correlation, positive at the knee and negative at the hip and ankle, could mean that the more stable they are, the more unstable the knee and vice versa. The higher LyE values relating to the ankle could indicate a particular role of this joint in the execution of the pedal stroke. A study on a larger sample is needed to confirm these results. Further studies could be conducted on the correlation between LyE and more objective parameters such as power expressed during pedalling.

### RELATIONSHIP BETWEEN ANTHROPOMETRY, FLEXIBILITY, STIFFNESS CHARACTERISTICS, STRENGTH QUALITIES, AND CHANGE OF DIRECTION IN BADMINTON ATHLETES

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#### INTRODUCTION:

Change of direction (COD) is deemed as the best physical predictor of badminton performance [1]. Identifying measures related to COD will be valuable for coaches and athletes to evaluate the badminton ability. Anthropometry, flexibility, stiffness characteristics, strength qualities were suggested as the components of badminton-specific assessment [2], but their relationship with COD was barely researched and has not been established. Therefore, the objective was to investigate the relationship between these physical qualities and COD in badminton athletes.

#### METHODS:

Twenty-six male (14 national-level:  $21.9 \pm 3.1$  yr,  $180.5 \pm 4.9$  cm,  $73.8 \pm 7.9$  kg; 12 provincial-level:  $16.6 \pm 1.5$  yr,  $179.4 \pm 5.3$  cm,  $69.5 \pm 10.6$  kg) and 24 female (10 national-level:  $19.8 \pm 2.0$  yr,  $167.2 \pm 4.7$  cm,  $60.6 \pm 5.7$  kg; 14 provincial-level:  $14.8 \pm 1.4$  yr,  $164.8 \pm 3.8$  cm,  $53.9 \pm 4.3$  kg) right-handed badminton athletes were recruited. Leg length and body fat were measured with tape and skinfold calliper respectively; flexibility was assessed by Y-balance test; stiffness of vastus lateralis (VL), gastrocnemius lateralis (GL), gastrocnemius medialis (GM), Achilles tendon (AT), and patellar tendon (PT) for both sides were evaluated by MyotonPRO device; peak torque of quadriceps and hamstring in both limbs were quantified with a hand-held dynamometer in seated position. Last, a Badminton Half-Court Agility Test of COD was conducted [3].

#### RESULTS:

The relationship between physical qualities and COD was investigated using Pearson and Spearman (body fat) product-moment correlation coefficient. There was a strong, positive correlation between right PT stiffness ( $1374.64 \pm 155.21$  N/m,  $r = 0.547$ ,  $p = 0.043$ ) and COD ( $14.58 \pm 1.26$  s) in male national-level athletes; a strong, positive correlation between body fat ( $9.98 \pm 3.26\%$ ,  $r = 0.575$ ,  $p = 0.05$ ), left posterolateral reaching distance ( $95.2 \pm 7.0\%$ ,  $r = 0.732$ ,  $p = 0.007$ ) and COD ( $14.83 \pm 0.89$  s) respectively in male provincial-level athletes; a strong, negative correlation between right Achilles tendon stiffness ( $1586.33 \pm 252.52$  N/m,  $r = -0.583$ ,  $p = 0.047$ ), right posteromedial reaching distance ( $107.36 \pm 5.83\%$ ,  $r = -0.709$ ,  $p = 0.01$ ) and COD respectively in male provincial-level athletes. No significant correlation was found between physical qualities and COD in female national- and provincial- level athletes.

#### CONCLUSION:

Our finding suggested lower right PT stiffness of national-level male badminton athletes; less body fat and left posterolateral reaching distance, higher right posteromedial reaching distance and AT stiffness of provincial-level male badminton athletes may relate to better COD performance. Physical qualities may not relate to COD performance in female badminton athletes. The results could provide diagnostic tools and information to enhance COD performance.

#### REFERENCES:

1) Hughes & Cosgrove, Assessment of elite badminton athletes, 2007



- 2) Paterson et al., Strength Cond J, 2016  
3) Maloney et al. J Appl Biomech, 2014

### KNOWLEDGE OF RESULTS DURING VERTICAL JUMP TESTING: AN EFFECTIVE METHOD TO INCREASE THE PERFORMANCE BUT NOT THE CONSISTENCY OF VERTICAL JUMPS

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#### INTRODUCTION:

Vertical jumps are commonly used to evaluate the function of lower-body muscles (3). Besides recording the maximal jumping performance, the reproducibility of the obtained outcomes during the test should be high (1). Additionally, it has also been reported that the provision of jump height feedback (i.e., KR) enhances short- and long-term vertical jump performance (2) which was assumed to rely on increases in motivation and competitiveness (2). Therefore, this study aimed to determine whether the provision of jump height feedback (knowledge of result; KR) can increase (a) the performance and (b) the consistency of output variables commonly reported during vertical jump testing procedures.

#### METHODS:

Sixteen subjects (6 women) were tested on 4 sessions during 2 consecutive weeks. The sessions were randomly performed and consisted of (I) squat jump (SJ) without KR, (II) SJ with KR, (III) countermovement jump (CMJ) without KR, and (IV) CMJ with KR. Six maximal jumps were randomly performed in each session: 3 trials from a 90° knee angle and 3 trials from the self-preferred knee angle. All jumps were performed on a force platform (Dinascan/IBV, Valencia, Spain). During the sessions which were performed with KR, jump height was provided after each jump.

#### RESULTS:

The provision of KR significantly increased peak force ( $p = 0.046$ , 1.83%), mean force ( $p = 0.037$ , 1.45%), peak velocity ( $p < 0.001$ , 3.71%), mean velocity ( $p = 0.004$ , 3.44%), peak power ( $p < 0.001$ , 4.22%) and mean power ( $p = 0.001$ , 4.69%). A high within-session reliability was observed for all variables (coefficient of variation [CV]  $\leq 5.62\%$ , intraclass correlation coefficient [ICC]  $\geq 0.95$ ). No systematic differences in reliability were detected between the jumps performed without KR (CV =  $3.00 \pm 1.38\%$ , ICC =  $0.97 \pm 0.03$ ) and with KR (CV =  $3.04 \pm 1.49\%$ , ICC =  $0.97 \pm 0.04$ ). Additionally, no differences in reliability were observed between the standardized 90° knee angle (CV =  $3.13 \pm 1.56\%$ , ICC =  $0.97 \pm 0.03$ ) and self-preferred knee angle (CV =  $2.91 \pm 1.29\%$ , ICC =  $0.97 \pm 0.04$ ) nor between the SJ (CV =  $3.00 \pm 1.56\%$ , ICC =  $0.97 \pm 0.05$ ) and CMJ (CV =  $3.04 \pm 1.29\%$ , ICC =  $0.98 \pm 0.02$ ).

#### CONCLUSION:

Confirming previous studies, the provision of the KR has shown to be an effective method to increase the magnitude of the mechanical variables commonly assessed with force platforms during vertical jump testing procedures. The novel finding of the present study is that the reliability of the mechanical variables was not affected by the feedback condition. Based on these results, it can be concluded that the provision of jump height feedback during vertical jump testing procedures is effective at enhancing vertical jump performance but, importantly, it does not affect the reliability of the outcome measures.

#### REFERENCES:

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Keller, et al. Journal of Sports Sciences, 2015  
Mandic, et al. Journal of Human Kinetics, 2016

### QUANTITATIVE AND QUALITATIVE MOTION ANALYSIS OF THE INITIAL MOVEMENT PATTERNS DURING MULTIDIRECTIONAL ACCELERATIONS

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#### INTRODUCTION:

The complex speed of movement, with its numerous manifestations, is a crucial component in many team and racket sports. Here, the ability to accelerate multidirectional and quickly is of outstanding importance (Lockie, et al., 2011). An approach to optimize this early acceleration, which has been little studied so far, is the comparison of different step patterns, related to the initiation of movement and the first steps. Accordingly, the aim of this study was to compare the effectiveness of the step patterns Jab Step (JS), Pivot Step (PS), Gravity Step (GS), Counter Step (CS) for lateral acceleration.

#### METHODS:

In the present investigation, 17 athletes (sex: 7 male, 10 female; age:  $23.6 \pm 2.9$  years; height:  $175 \pm 9.5$  cm; weight:  $70.5 \pm 13.2$  kg) of different team and racket sports participated, whose 5 m sprint times in both 90° lateral starting directions (left & right) were tested using the different initial step patterns. The subjects practiced the required step patterns on a familiarization session until their sprint time was stabilized within a deviation of 2.5%, relative to the fastest attempt. The step patterns were tested under single (SC) and double choice reaction conditions (DC). In a randomised sequence of the step patterns, three trials in both directions were performed under each condition, of which the fastest was chosen for the evaluation. In all tests, a 30 s rest between each run and a 3 min rest after three runs was taken to counteract fatigue effects. Starting signal and time measurement were recorded by means of a photoelectric double light cell, a coupled traffic light system as well as the associated control unit and software. With a camera positioned 4 m behind the subject, slow motion video was taken at a frame rate of 120 fps. To measure the ground reaction forces, a measuring sole system was applied.

#### RESULTS:

On average, under all reaction and direction conditions the fastest sprint times and higher ground reaction forces were measured for the JS. Significant differences ( $p \leq 0.05$ ) were found between JS and GS for the condition SC left ( $1.77 \pm 0.10$  s;  $1091 \pm 271$  N vs.  $1.82 \pm 0.07$  s;  $811 \pm 290$  N) as well as for the condition DC left ( $1.84 \pm 0.08$  s;  $1121 \pm 350$  N vs.  $1.92 \pm 0.90$  s;  $849 \pm 485$  N).

#### CONCLUSION:

The faster sprint times of the JS under all conditions indicate that this step pattern is most effective for accelerations in lateral directions. Matching this, the higher 1st step ground reaction forces at JS imply a stronger takeoff impulse. However, for many athletes, the JS may be the most intuitive step pattern for lateral acceleration, which would have an impact on the present results. For further clarification, future investigations should develop a detailed kinematic and kinetic profile of the step patterns.

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**BLOOD PRESSURE VARIATION AS INDICATOR OF AEROBIC PERFORMANCE**

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## INTRODUCTION:

Blood pressure (BP) gives important information on the status of the cardiovascular system. At maximal intensity exercise, physiological upper limits of systolic BP (SBP) have been found to be higher in elite endurance athletes than in elite athletes practising other sports [1]. Further, a lower exercise capacity has been described in athletes with higher SBP at rest [2]. Considering the linear relation between VO<sub>2</sub>, cardiac output and pressure on the vessels' wall, the aim of this study was to investigate the relation between BP variation and aerobic performance. It was hypothesised that maximal SBP variation (dSBP) correlated with the maximal aerobic capacity (VO<sub>2</sub>/kg max).

## METHODS:

18 healthy male cyclists from recreational to elite level volunteered to participate. The protocol was conducted in a laboratory and the exercise was performed on a cycle ergo-meter (Lode Excalibur Sport, Lode B.V., Netherlands). The protocol was constituted by 10 min of seated resting, 10 min of warm-up, lactate profile test, 10 min of break, maximal incremental test to exhaustion and second resting period. Blood lactate concentration and metabolic consumption were recorded during the two tests. BP was recorded every 2 min (first resting period, maximal incremental test to exhaustion and second resting period) or 5 min (warm-up, lactate profile test, 10 min of break) by using exercise-validated auscultatory method's upper-arm inflatable cuff with an integrated microphone to detect the Korotkoff sounds (Schiller PB-200+, Schiller AG, Switzerland). Maximal BP variation was calculated as the difference in mmHg between BP at the maximal intensity exercise and at rest.

## RESULTS:

This study found an average maximal variation of systolic BP (dSBP) of  $94 \pm 14$  mmHg and of diastolic BP (dDBP) of  $4 \pm 10$  mmHg. dSBP had low positive correlation with the VO<sub>2</sub>/kg max ( $r=0.35$ ,  $p<0.05$ ), whereas dDBP, pulse pressure (PP) at the maximal intensity exercise (exPP) and maximal variation of PP (dPP) had moderate correlation with the VO<sub>2</sub>/kg max ( $r=-0.55$ ,  $r=0.57$ ,  $r=0.56$ ,  $p<0.05$ ). dDBP had moderate negative correlation with all the aerobic performance indicators analysed: absolute VO<sub>2</sub> max, relative workload at the VO<sub>2</sub> max, absolute and relative workload at the lactate threshold ( $r=-0.51$ ,  $r=-0.50$ ,  $r=-0.50$ ,  $r=-0.54$ ,  $p<0.05$ ).

## CONCLUSION:

SBP varied considerably more than DBP during the course of the protocol. This finding is in line with previous studies [1], [3], [4]. However, the latter revealed a stronger correlation with all the aerobic performance indicators analysed, in contrast to what was hypothesised based from the literature. ExPP and dPP showed moderate positive correlation with VO<sub>2</sub>/kg max, as could have been speculated by calculations made from the results of a previous study [1]. The findings from this study add knowledge to the relation between BP variation and aerobic performance in healthy endurance athletes.

1. Caselli et al. (2016) 2. Mazic et al. (2015) 3. Kurl et al. (2001) 4. Sieira et al. (2010)

**ASSOCIATION OF PHYSIOLOGICAL LOAD MARKERS WITH MAXIMAL EXERCISE TESTING IN HIGH INTENSITY FUNCTIONAL TRAINING**

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## INTRODUCTION:

High-intensity functional training (HIFT) aims to concurrently improve multiple fitness domains (e.g. strength and endurance). Coaches can use physiological load markers to assess individual training responses and make programming modifications to optimize outcomes. Heart rate variability (HRV) – an index of autonomic nervous system activity – has been used to assess responses to training in endurance sports with promising results. Additionally, testosterone (T), cortisol (C) and their ratio (T:C; a measure of physiological load) have been positively linked with changes in maximal strength. The ability to relate HRV and T:C to the status of fitness domains would provide timely insight into potential performance abilities based on an athlete's response to the training program, however these relationships have yet to be investigated for HIFT. Our aim was to determine if positive linear relationships existed between daily resting HRV and endurance (VO<sub>2</sub>max) as well as between T:C ratio and maximal strength during HIFT.

## METHODS:

Thirty recreationally active men ( $n = 13$ ,  $24.7 \pm 4.5$  years) and women ( $n = 17$ ,  $25.7 \pm 4.7$  years) participated in a 9-week HIFT intervention (5 days/week for 60-minute sessions). Daily HRV readings were obtained upon waking in a supine position via the smart phone application HRV4Training photoplethysmography (PPG). Saliva samples were taken prior to maximal strength testing and were analyzed for concentrations of T:C via an enzyme-linked immunosorbent assay. HRV and T:C data were checked for normality; both were transformed using the natural log method prior to statistical analysis. VO<sub>2</sub>max was assessed using the Bruce protocol with a validation pre- and post-intervention. Combined maximal strength (CFT) consisting of a one-repetition max for back squat, overhead press and deadlift was assessed at pre, mid, and post-intervention. Linear regression analyses were performed. Potential outliers were assessed using the Cook's distance metric; with no influential outliers identified.

## RESULTS:

The model of best fit found that HRV ( $n = 57$ ) accounted for 23% of the variance in VO<sub>2</sub>max ( $F(1,55) = 16.33$ ;  $p < 0.001$ ;  $R^2 = 0.23$ ). For every one unit increase in HRV there was a 3.16 ml/kg/min increase in VO<sub>2</sub>max ( $\beta = 3.16$ , 95%CI = 1.59, 4.72;  $t = 4.04$ ;  $p < 0.01$ ). The regression model found that T:C ( $n = 23$ ) did not significantly predict the variance in CFT ( $F(1,25) = 3.59$ ;  $p > 0.05$ ;  $R^2 = 0.15$ ).

## CONCLUSION:

We found a positive linear relationship between daily resting HRV and endurance for HIFT participants. Possibly due to a smaller sample size, we found no significant relationship between T:C and strength. Coaches may find utility in daily resting HRV monitoring as an estimate of current endurance adaptations throughout a HIFT training cycle. Future research should re-examine these relationships with a larger sample and explore the use of load markers to predict individual performances.

## CARDIOVASCULAR REFLEX TESTS AND HEART RATE VARIABILITY IN ELITE ATHLETES AND IN SEDENTARY CONTROLS

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### INTRODUCTION:

The cardiovascular system is controlled by autonomic regulation of sympathetic and parasympathetic pathways of the autonomic nervous system. Exercise training has beneficial metabolic and neurovegetative effects for preventing cardiovascular diseases due to decreasing sympathetic and increasing parasympathetic activity and baroreflex sensitivity. Earlier studies demonstrated higher resting diastolic blood pressure in water polo players than in sedentary controls. Systolic blood pressure was higher in water polo players and synchronised swimmers compared to endurance dry-land athletes. The early diagnosis of cardiovascular autonomic neuropathy (CAN) is very important among athletes.

### METHODS:

The aim of our present study was to investigate the cardiac autonomic regulation and heart rate variability in aerobic endurance trained athletes: in rowers (n=17), and in team sport players: in water polo players (n=17) and in sedentary controls (n=7). Cardiovascular reflex tests using Ewing method (deep breathing test, Valsalva manoeuvre, handgrip test, orthostatic test) were performed using Cardiosys Extra system (MDE Heidelberg). ECGs were recorded, and heart rate variability (HRV) parameters were analysed.

### RESULTS:

Systolic and diastolic blood pressure (BP) values were higher in water polo players than in rowers and in controls. The values in 30/15 ratio in rowers ( $p < 0.001$ ) and in water polo players ( $p < 0.0001$ ) decreased compared to controls, but it remained between the normal values. The diastolic BP changes after sustained handgrip showed mild CAN in water polo players and in rowers. Comparison of the AN Scores rowers and water polo players had significant higher values than in healthy individuals. The HRV time domain parameters: SDNN, pNN50 and rMSSD were higher in rowers ( $p < 0.05$ ) compared to controls. rMSSD were higher in water polo players ( $p < 0.05$ ) than in controls. LF/HF proportion differs significantly between water polo players and controls.

### CONCLUSION:

The enhanced sympathetic activity and diminished parasympathetic modulation may influence the incidence of water polo player's hypertension. Recognizing early signs of cardiovascular autonomic neuropathy would like to draw attention to prevent overtraining and the need for prevention of further cardiovascular complications.

## CP-AP11 Sports technology and monitoring

### COMPARISON OF THE DIFFERENT PERFORMANCE VARIABLES BETWEEN FORCE PLATFORM AND MYJUMP APPLICATION IN FEMALE PROFESSIONAL FOOTBALL PLAYERS

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### INTRODUCTION:

The vertical jump has been the most used task to evaluate the mechanical capacities of lower limbs (García-Ramos et al. 2017). According to Samozino et al. (2008), vertical jumping is a reliable tool for the evaluation of the lower limb extensor muscles ( $P < 0.98$ ). Objective: Compare the different performance measures between a force platform and MyJump application in Squat Jump (SJ) and Countermovement Jump (CMJ).

### METHODS:

5 healthy female Spanish professional football players (age:  $25.0 \pm 4.30$  years, height  $1.60 \pm 0.05$  m, body mass:  $55.90 \pm 5.01$  kg, and body mass index:  $21.82 \pm 1.45$ ), participated in the study. Athletes completed 1 session consisted of measuring the height of the jumps based on the takeoff speed (SP) or the flight time (FT), in 5 repetitions of SJ and CMJ, with 30 seconds recovery between trials and 2 minutes between different kind of jumps with a force platform (FP) and MyJump application (APP) at the same time. Mean differences between the measurements was determined using a paired samples t-test. Significance was set at  $p < 0.05$ .

### RESULTS:

SJ height measured by FP SP was  $45,22 \pm 2,72$  cm vs APP FT  $32,33 \pm 1,99$  cm ( $P = 0,002$ ), FP FT  $32,56 \pm 1,77$  cm vs APP FT  $32,33 \pm 1,99$  cm ( $P = 0,324$ ) and FP SP  $45,22 \pm 2,72$  cm vs FP FT  $32,56 \pm 1,77$  cm ( $P = 0,001$ ). And CMJ height measured by FP SP was  $35,86 \pm 2,39$  cm vs APP FT  $34,11 \pm 3,66$  cm ( $P = 0,165$ ), FP FT  $36,34 \pm 2,65$  cm vs APP FT  $34,11 \pm 3,66$  cm ( $P = 0,061$ ) and FP SP  $35,86 \pm 2,39$  cm vs FP FT  $36,34 \pm 2,65$  cm ( $P = 0,078$ ).

### CONCLUSION:

Our preliminary results show significant differences in SJ between the parameters based on the takeoff speed (SP) vs flight time (FT), either on the force platform or with the MyJump application. However, there are no differences in CMJ between both measure ways. Our SJ data based on FT agree with the FT showed in the literature in elite sportswomen ( $33 \pm 0,2$  cm) (Jimenez-Reyes et al. 2018). It seems that SJ height could be overestimated vs SJ height measured with a FP and SP. Therefore, a reliable and accurate tool that measures jump height based in speed flight would be the best way to measure high level sportswomen.

### SHORT PHYSICAL-COGNITIVE (WORK) BREAKS TO IMPROVE COGNITIVE FLEXIBILITY VIA EXERGAMING

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Workplace health promotion is widely discussed but hard to apply sustainably. Short active breaks, especially for sedentary workers, might not only reduce the risk of cardiovascular and metabolic diseases, but also boost cognitive performance. Certain cognitive functions, e.g. executive functions, have been shown to be enhanced after acute physical exercise. It is rather unknown if acute physical exercise with a cognitive component (dual-domain training), can also improve executive functions. Our objective was to assess possible acute effects of a video game-based physical-cognitive exercise (exergame) as a work break on cognitive flexibility in employees. 26 healthy, employed participants aged 21 to 55 years were either allocated to experimental (EG;  $n = 17$ ,  $31.71 \pm 10.8$  years, 9 male) or control (CG;  $n = 9$ ,  $32.45 \pm 7.43$  years, 5 male) group. The CG watched a documentation in a seated position (25min), comparable to a sedentary work break. The EG completed a 25min functional interval training with the ExerCube (Sphery Ltd.; targeting 90% of maximum heart rate), representing a

physical-cognitive work break. Cognitive flexibility was assessed by a Switching-Stroop task (randomized switch between two task assignments: color naming/Stroop + reading/modified Stroop) at day 1 (familiarization) and before, 1min and 15min after the intervention at day 2. Reaction time (RT) and performance accuracy (ACC) of the general task and the two task assignments were analyzed. For the comparison of interventions and task switch, 3 (time) × 2 (group) [× 2 (task assignment)] repeated measures ANOVAs and Bonferroni corrected post-hoc tests were calculated. Both groups improved their performance across measurements with higher performance of EG. Performance with the modified Stroop task was superior to performance with Stroop task for both groups (EG, CG) and parameters (RT, ACC). For the general task, we found a significant time × group interaction for ACC ( $F(1, 2) = 4.581, p = .015, \eta p^2 = .160$ ), driven by large improvements of the EG. Analyses comparing the two task assignments revealed a significant task effect ( $F(1, 2) = 14.459, p = .001, \eta p^2 = .376$ ) and a task × group interaction ( $F(1, 2) = 4.351, p = .048, \eta p^2 = .153$ ) for ACC with the EG revealing higher improvements from before to 15min after intervention. Currently, further CG participants are tested to secure appropriate group size. According to our results, a work break via exergaming seems to potentially boost the performance accuracy of cognitive flexibility in employees. In order to overcome inactivity and maintain participation, a challenging and long-term motivational character of work breaks via the inclusion of a gaming component might provide a sustainable solution. Assimilation of group sizes will finalize the study results and enable to test for influencing factors such as composition, timing and learning effects of cognitive testing or duration, intensity and motivation of physical exercise.

### EVALUATING THE EXERCISE INTENSITY DURING AN EXERGAME SESSION IN THE EXERCUBE

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#### INTRODUCTION:

Exergames are a new generation of interactive video games that stimulate an active, whole-body gaming experience (1). By combining electronic entertainment with physical exercise, exergames offer novel opportunities to expand physical activity in different age groups and settings. Even though studies have found a significant increase in energy expenditure when playing exergames compared to normal video games, most games only induce low to moderate-intensity activity that is said to be too low to result in relevant physical adjustments (2). In the present study, the exercise intensity of a new, functional fitness game called the ExerCube (by Sphery Ltd) (3) was assessed.

#### METHODS:

20 healthy subjects (mean age  $24.5 \pm 3.8$  yrs; 50% female; BMI  $23.2 \pm 2.2$  kg/m<sup>2</sup>; maximal oxygen consumption (VO<sub>2</sub>max)  $49.2 \pm 6.13$  ml/kg/min) were enrolled in this study. VO<sub>2</sub>max (MetaMax 3B Cortex) and maximal heart rate (HRmax) (RS 800, Polar) were assessed during a maximal graded exercise test on a treadmill and compared to oxygen consumption (VO<sub>2</sub>) and heart rate (HR) during a game (25 minutes) in the ExerCube.

#### RESULTS:

In the ExerCube the participants reached a maximal HR of  $188.9 \pm 8.69$  bpm which corresponds to  $96.90 \pm 3.34\%$  of their individual HRmax. The mean HR throughout the 25-minute game was  $168.90 \pm 9.22$  bpm corresponding to  $86.64 \pm 3.70\%$  of HRmax. VO<sub>2</sub>peak during the training in the ExerCube reached  $41.15 \pm 5.43$  ml/kg/min which is equivalent to  $83.78 \pm 6.38\%$  of VO<sub>2</sub>max. The mean VO<sub>2</sub> consumption during the game reached  $31.8 \pm 4.11$  ml/kg/min equaling  $64.83 \pm 5.5\%$  of VO<sub>2</sub>max.

#### CONCLUSION:

Playing in the ExerCube is a form of vigorous physical activity that not only achieves but exceeds the intensity recommendations of the American College of Sports Medicine (ACSM) for developing and maintaining cardiorespiratory fitness and health (4). Due to its playful, immersive and motivating character, the ExerCube seems to be a promising and appealing tool to facilitate physical activities.

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### AN ANALYSIS OF AERODYNAMIC CHARACTERISTICS DURING SKI JUMPING USING WEARABLE CENTIMETER-LEVEL GNSS

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#### INTRODUCTION:

Flight phase of ski jumping involves two forces: gravity and aerodynamics. Aerodynamic characteristics such as lift-to-drag ratio (L/D) are very important because flying at the highest L/D maximizes the flight distance in gliding flight starting from the same altitude. Recently, high-accuracy positioning using kinematic GNSS becomes common, which achieves accuracy at centimeter-level by using carrier-phase enhancement. The purpose of this study is to apply kinematic GNSS to analyse the aerodynamic characteristics in the flight phase of ski jumping.

#### METHODS:

One male university student ski jumper cooperated with this measurement. He performed ski jumping with a wearable kinematic GNSS (AT-H-02, 78x38x18 mm<sup>3</sup>, 69 g, Miyamoto et al., 2017) and an antenna (TW2712, Tallysman) on his head. The sampling frequency is 10 Hz. GPS, BeiDou and QZSS satellite systems were used. Flight trajectories of his ski jumps were recorded three times at Okurayama Schanze (HS=137, K=123m, JAPAN) in July 2019. A base station (BD982, Trimble) with an antenna (HG-GOYH8201) was set up in the Schanze. The raw data obtained from GNSS was converted to 3D position and velocity data using a post-processing kinematic software (RTKLIB) and Hubenys formula. The position data was smoothed by Savitzky-Golay filter. Using these data, acceleration, direction of flight, and then lift and drag forces were calculated. L/D is obtained by dividing lift force by drag force.

#### RESULTS:

GNSS fix rate during flight was 93.3% on average. There were float solutions after takeoff and just before landing. Number of satellites decreased to 9 for 0.5 seconds after takeoff. Other than that it was 15. Positioning errors (s.d.) were 2.1-3.7 cm in horizontal and 3.2-3.4 cm in vertical for 0.7 seconds after takeoff. Other than that they were 0.9-1.0 cm in horizontal and 1.8-1.9 cm in vertical. Lift force was 700 N at

takeoff, decreased to 160 N 0.7 seconds after takeoff, and then gradually increased to 500 N at landing. Drag force was 20-100 N at takeoff and gradually increased to 440 N at landing. L/D was unstable immediately after takeoff, but it was 1.78 0.7 seconds after takeoff, and then gradually decreased to 1.14 at landing. Direction of flight was -2 deg. at takeoff and then gradually decreased to -42 deg. at landing.

### CONCLUSION:

By using kinematic GNSS, trajectory of ski jumping was measured within positioning error of 2 cm on average, resulting in aerodynamic characteristics during flight. The positioning accuracy was deteriorated for 0.5-0.7 seconds after takeoff and 0.1-0.3 seconds before landing due to changing posture of the jumper. During stable flight L/D was gradually decreased. Since higher L/D achieves further flight distance, it is suggested that acquiring higher L/D immediately after takeoff and keep L/D high until landing are very important for ski jumping. Therefore evaluation of L/D using wearable kinematic GNSS is valuable for ski jumpers.

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## ASSESSING VERTICAL DROP IN ALPINE SKIING BY TWO SENSORS INCORPORATED IN AN IMU: BAROMETER VERSUS GLOBAL POSITIONING SYSTEM MEASUREMENTS

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### INTRODUCTION:

Vertical drop (VD), is a key parameter in alpine skiing performance and it is directly related with the steepness of the slope [1,2]. For Olympic Winter Games, FIS World Ski Championships and FIS World Cups, the International Ski Federation (FIS) has regulated the VD from start to finish in each discipline [3]. In the ski field, the studies that assess terrain characteristics often used camera-based motion analysis or digital terrain model systems [1,2,4]. Although it is the most accurate method, it is a very time-consuming and requires specialized personnel. The application of inertial measurement units (IMU's) in skiing could be an alternative method to collect and analyze accurate terrain data. The aim of this study is to assess reliability of barometer (BAR) and global positioning system (GPS) sensors incorporated into a Wireless Inertial Measurement Unit (WIMU) to assess VD and elevation. It also aim to compare both sensors with referenced geodesic vertexes.

### METHODS:

Three WIMUS (Realtrack systems) were placed to an experienced skier. For two days, the skier went down three different ski slopes divided into four stop points where the skier had to stop for a minute. Non-consecutively duplicate measurements were registered for each stop. Other than that, five geodesic vertexes located at different highs were measured with the WIMUS on two different days. Each day, triplicate measurements of one minute long were made by each WIMU at the same time. Elevation data recorded by BAR and GPS sensors was analyzed and VDs were calculated as elevation differences between two points. Intraclass correlation (ICC), technical error of measurement (TEM) and coefficient of variation (CV) were applied for test-retest and inter-rater reliability. Wilcoxon, Kruskal-Wallis and U de Mann-Whitney tests were used to assess differences between WIMU's in both sensors. A one way ANOVA was used to detect changes between BAR, GPS and geodesic vertex for both elevation and VD measurements.

### RESULTS:

When assessing VD, high test-retest and inter-rater reliability was obtained with both sensors, ICC > 0,999 (95% CI = 0,999–0,999). TEM < 0,05% and CV < 5% also show a high reliability. When measuring elevation, significant differences found in the Kruskal–Wallis H (H = -6, 585, p = 0,04) and in the Wilcoxon (Z = -2,708, p = 0,01) tests compromised BAR and GPS reliability. A One Way Anova revealed no significant differences between BAR, GPS and geodesic vertex when assessing VD (F=0,028, p=0,972). Despite this, to assess elevation, significant differences were found between BAR and geodesic vertexes (F=24,871, p=0,000), but not between geodesic vertexes and GPS (t=-0,289, p=0,773).

### CONCLUSION:

BAR and GPS sensors incorporated in a WIMU device demonstrate a high reliability, referring to VD measurements. Both sensors were also accurate when comparing to geodesic vertexes. However when measuring elevation, only GPS sensor would be a reliable and accurate sensor as long as the WIMU is located in an uncovered place

## A NEW METRIC TO ESTIMATE THE MECHANICAL LOAD USING WEARABLE ACCELEROMETERS

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### INTRODUCTION:

The Player Load™ is a widely used parameter for physical demand quantification using wearable accelerometers. However, its calculation reveals a potential issue. Player Load™ is defined as the square root of the sum of the squared instantaneous change in acceleration on each individual component (3 axes). Given that components of a vector depend on its reference frame, accelerations (including gravity) are projected in different ratios on the accelerometer axes whenever the wearable device is rotated. Consequently, a fictitious rate of changes in acceleration components is generated by the device orientation changes. We proposed a new mechanical load index, the AccelRate™. Based on the instantaneous changes in the modulus of the 3-axes acceleration vector, the AccelRate™ was developed to solve the Player Load™ theoretical issue: as opposite to each component of a vector, the modulus does not depend on the reference frame.

The aims of this study were therefore i) to assess the concurrent validity of the Player Load™ provided by accelerometers compared to the reference values using force plates; ii) to propose a new metric, the AccelRate™, in order to overcome the abovementioned theoretical issue.

### METHODS:

Twenty-one recreational males performed running-based movement at both low and high intensity over six in-series force plates (KI 9067; Kistler, piezoelectric sensors; 1.2 × 0.6 m). Participants were instrumented with two triaxial accelerometers (Minimax S4, Catapult) positioned at the upper and lower back. We examined the validity of the Player Load™ and the AccelRate™ by using force plates.

### RESULTS:

The SEE were “small” to “moderate” for all tested conditions for the Player Load™ (0.45 - 0.87) and the AccelRate™ (0.25 - 0.95). However, while the Player Load™ displayed systematic “very large” to “extremely large” mean biases (17.1 - 226.0), the AccelRate™ displayed “trivial” to “small” mean biases (-1.0 - 6.1).

### CONCLUSION:

The present investigation shows, first, that the Player Load™ did not match the mechanical load applied to the players center of mass in ecological conditions using in-series force plates. Second, the Accel'Rate™ presented good to very good validity for various exercises executed at different intensities. Third, the movement intensity strongly altered the accuracy and agreement of the measurements of the Player Load™ compared to the Accel'Rate™, which remained robust regardless of the exercise intensity. Therefore, Accel'Rate™, based on instantaneous variations of the modulus of the 3-axes acceleration vector, appears more suitable to reflect the mechanical load elicited by various physical activities. This study provides an innovative and robust mechanical load index easily accessible during sport training and competition.

### CLASSIFICATION OF ALPINE SKIERS SKILL LEVEL USING SMARTPHONE DATA

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#### INTRODUCTION:

The use of smartphones as activity trackers over the last few years has increased exponentially. The release of different sensors and apps have amplified the possibilities of tracking and evaluating alpine skiing. However, the wide range of skier skill levels is a factor to take into consideration when comparing metrics between skiers or including gamification into tracking. Consequently, the aim of this project was to develop a skill level classification tool for alpine skiers based on smartphone data.

#### METHODS:

Data was collected from 31 skiers (14 intermediate, 11 advanced and 6 expert). The skiers were instructed to simply turn on the app and keep it running through the entire session. They had to ski for at least half a day, record a video of them skiing and fill a questionnaire after the skiing day.

The data was collected using a customized app that recorded barometer, GPS, accelerometer and gyroscope signal from the smartphone sensors. The video was used by expert raters to assess the level of the skiers. The questionnaire was used to report if they were skiing alone or in a group and the skiing background.

Shapiro-Wilk test was used to assess normality. To avoid multicollinearity, variables with a correlation higher than 0.8 were removed. The between group comparisons were assessed by means of 1-way ANOVA and Kruskal-Wallis test for normal and non-normally distributed variables respectively. Bonferroni post-hoc pairwise comparisons were used when significant differences were found. To classify the data into the three groups, a decision tree was trained. Significance was assessed at  $\alpha = 0.05$ .

#### RESULTS:

An activity detection algorithm to differentiate between skiing, being on the lift and being stopped was developed. Different thresholds such as instantaneous speed and altitude difference were used to determine the outcome. Based on those results and the raw data 44 metrics were extracted, such as: speed, active time, pause duration, altitude changes, etc. After multicollinearity analysis 30 variables were included for further analysis. Differences between groups were found for maximum speed ( $p < 0.001$ ), average speed ( $p < 0.001$ ), minutes skiing ( $p = 0.001$ ), minutes stopped before the lift ( $p = 0.039$ ), total pause time ( $p = 0.049$ ), number of stops during runs ( $p = 0.011$ ), and the ratio between the active time and the time at the bottom of the lift ( $p = 0.022$ ). The results of the decision tree showed a training accuracy of 80.6% based on two variables: average speed (25 km/h) and total pause during skiing (68').

#### CONCLUSION:

The results of this study highlight differences in some metrics between intermediate, advanced and expert skiers. Although the decision tree classifies properly 80.6%, all the data was used as a training set due to the small sample. We conclude that the results indicate the feasibility of classifying the skiers' skill based on smartphone data but more data is needed to further improve and validate the classification model.

### ASSOCIATION OF PERCEIVED FATIGUE WITH GAIT AND HEART RATE DURING HALF MARATHON RUNNING USING BODY WORN SENSORS

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#### INTRODUCTION:

Running technique is one of the crucial factors that explain the change in performance and economy in runners' skills levels [1]. Fatigue has been shown to introduce changes in running technique, like shifting the landing mechanics from front-foot to midfoot running [2], change in contact and aerial times [3]. A decrease in heart rate variability (HRV) has also been observed during sport-induced fatigue [4]. However, the influence of fatigue of the above-mentioned metrics have mainly been explored in laboratory or in field intermittently. The aim of this study was to assess, continuously during half-marathon, the influence of fatigue on running movement and heart rate.

#### METHODS:

19 recreational runners were equipped during the Lausanne and Geneva half-marathon with an IMU (Gait Up, CH) on each foot and a combined GPS-IMU-ECG sensor (ASI, CH) attached to a chest belt. A specially developed smartphone application recorded Rating of Fatigue (ROF) [5], every 10 minutes through verbal communication. Spatio-temporal gait parameters were extracted from the feet IMU data using a dedicated algorithm [6]. Statistical and complexity metrics of HRV and gait parameters were calculated over 10-minutes window. Two nonlinear approaches were explored [7]: 1) Poincare plot via short (SD1) and long-term (SD2) variability and 2) detrended fluctuation analysis via short-term fractal scaling exponent  $\alpha$ .

#### RESULTS:

Based on result observations, a ROF value equal to 6 (10 is "total fatigue & exhaustion") was selected as onset of fatigue (OF), defined as "the inability to maintain the required or expected force" [8]. The half-marathon participants typically showed an increased coefficient of variation for cadence and higher asymmetry index for contact time after OF. The ratio SD1/SD2 of HRV highly increased after departure, reaching maximum values at OF, mainly due to a decrease of SD2. The scaling exponent  $\alpha$ , extracted from RR-interval time series, significantly decreased after 10 minutes of running (from 1.5 to 1), and reached minimum values ( $\sim 0.5$ ) at OF. The decrease of SD2 and  $\alpha$  suggest a reduction in long-term oscillations in heart rate [9].

#### CONCLUSION:

The main contribution of this study was the continuous measurements of gait biomechanics, heart rate and ROF during half-marathon. Perceived fatigue during endurance running seems to be associated with higher gait variability and lower variability of heart rate. The results of this work will be extended further via statistical testing.

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**ESTIMATION OF INSTANTANEOUS SPRINT VELOCITY WITH A WEARABLE GNSS-IMU SENSOR USING A SENSOR FUSION APPROACH**

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INTRODUCTION:

Power-Force-Velocity profile obtained during the sprint test is crucial for designing personalized training and evaluating injury risks [1]. Predominant method of estimating the instantaneous velocity [2] assumes it to have a first order exponential behavior. While this method provides ease of use, the sprint velocity profile for all athletes may not show an exponential behavior. Alternately, velocity profile can be estimated using inertial sensors [3], with a speed radar, or a smartphone application [4]. However, [3] requires timing gates for drift removal while [4] provides only the mean speed. Thus, there is a need for a wearable sensor-based velocity estimation algorithm for the sprint test. The proposed method solves this problem using a sensor fusion approach, by combining the signals from wearable GNSS and IMU sensors.

METHODS:

To develop and validate our algorithm, we collected data from nine elite sprinters equipped with a wearable GPS-IMU sensor (Fieldwiz), who ran two trials each of 60m and 30m/40m sprints. In our algorithm, we utilized a gradient descent-based filter [5] as an orientation filter, which simplified our model to a linear one-dimensional model, thus allowing us to use a simple Kalman filter (KF) as a velocity/acceleration filter. We used two cascaded KFs, first to segment the sprint data precisely, and subsequently to estimate the velocity during sprinting and the sprint duration. We validated the estimated velocity and duration with speed radar and photocell data as reference.

RESULTS:

The mean percentage error of the estimated velocity w.r.t the radar speed profile ranged from 6% to 8%, while that for the estimated sprint duration lied between 0.1% to -6%. In case of the maximum velocity, the Bland-Altman plot showed close agreement between the estimated and the reference values, with all the values lying between two standard deviations. Examination of fitting errors indicated a second order exponential behaviour for the sprint velocity profile, unlike the first order behaviour previously suggested in literature.

CONCLUSION:

The proposed sensor-fusion algorithm has been validated to compute an accurate velocity profile with respect to the radar; it can compensate for and improve upon the accuracy of the individual IMU and GNSS velocities. This method will thus enable the use of wearable sensors in the analysis of sprint functional test.

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**ON THE USE OF BEAST ACCELEROMETER FOR BARBELL VELOCITY MEASUREMENT IN THE BACK-SQUAT**

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INTRODUCTION:

The force exerted by the athlete and the resulting velocity of the movement can be measured via force plates and linear position transducer (LT). Recently, low-priced accelerometers have been used to measure barbell displacement velocity (1). Barbell velocities can be used to generate Force-Velocity profiles (FV) for individual exercises and athletes and used to compute the one repetition maximum (1RM) indirectly (2). 1RM is best estimated with velocities obtained from overloads ranging from 20% to 70% of 1RM (3). "Beast" accelerometer (Beast Technologies S.r.l., Brescia, Italy) is a device widely used and its validity, reliability, and repeatability were tested for loads ranging from 50% to 100% of 1RM only (1). This study aims to analyze the validity and accuracy of the Beast device for the measurement of barbell velocity with loads ranging from 20% to 70% of 1RM and test the accuracy and validity of the 1RM estimate in the back-squat exercise.

METHODS:

18 rugby players (22.0±2.9years, 1.80±0.07m, 87.4±9.2kg) were recruited. 96h after testing their back-squat 1RM directly, players performed five sets of two repetitions with incremental loads ranging from 20% to 90% of their 1RM. Barbell velocity was simultaneously measured using a LT and the Beast accelerometer (BA) (1). To assess accuracy, paired samples t-test and Bland-Altman Plots were used to identify potential systematic bias (1), standard error of the estimate was also used to report the typical error of the measurements compared with the LT. Validity was tested using Pearson's product-moment correlation coefficient (r) (1). Moreover, BB 1RM and LT 1RM estimate (2) from FV accuracy, via Bland-Altman Plots and one-way ANOVA, and validity were tested in comparison to the 1RM directly assessed.

RESULTS:

The measurements of barbell velocity showed a high correlation between LT and BB ( $r=0.91$ ,  $p<0.001$ ,  $SEE=0.08\text{m/s}$ ). No systematic bias was found ( $p=0.114$ ). Analysis of the linear regression of the Bland-Altman plot showed consistent differences across the whole range of velocities ( $r^2=0.036$ ). The directly assessed 1RM showed a high correlation with both BA 1RM ( $r=0.826$ ,  $p=0.001$ ,  $SEE=10.7\text{kg}$ ) and LT 1RM ( $r=0.876$ ,  $p<0.001$ ,  $SEE=9.2\text{kg}$ ) estimates, with no systematic bias ( $p=0.157$ ).

#### CONCLUSION:

Beast accelerometer is accurate and valid for the measurement of barbell velocity in back-squat across a broader range of loads than previously presented (1). 1RM estimate is also valid and accurate, caution should be used for its application for prescribing of training due to high SEE.

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### FIRST-IN-ASIA APPLICATION OF CARDEA 20/20 ECGTM AUTOMATED DIGITAL ECG DIAGNOSTIC SYSTEM: COMPARATIVE ANALYSIS AGAINST CONVENTIONAL ECG IN ELITE ATHLETES

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#### INTRODUCTION:

Sudden cardiac events secondary to arrhythmias, conduction abnormality, cardiomyopathies and congenital heart disease can have devastating impact on elite athletes. Electrocardiography (ECG) screening is widely performed as a pre-participation assessment for elite athletic training and competition. Most institutions use conventional ECG systems (CON) not specifically designed for athletes. Recently, the Cardea 20/20 digital ECGTM system (Cardea) was developed with automated diagnostic algorithm for athletic use. In this study, we compared Cardea against CON in the machine detection and reporting of ECG parameters commonly interpreted by sports cardiologists.

#### METHODS:

The study population included elite athletes at the Hong Kong Sports Institute. Twelve-lead 10-second ECG was first recorded by CON (ECG-1350K, Nihon Kohden, Japan) followed immediately by Cardea (Cardiac Insight, Washington, USA) using the same electrode system. ECG data were extracted by physicians. For harmonisation of machine interpretation of Normal versus Abnormal ECGs, we used a Boolean approach to re-classify CON machine-flagged Abnormal ECGs as TRUE and Normal or Borderline ECGs as FALSE, whereas Cardea-specified review of ECGs was kept unchanged as TRUE or FALSE. Quantitative data were analysed using Pearson's correlation and Bland-Altman plot. A statistical level of  $P<0.05$  was considered significant.

#### RESULTS:

Among 49 elite athletes recruited, 32 (65%) were male with a mean age ( $\pm$ SD) of  $23.0\pm 6.8$  years (range: 11.0-42.4). 39 (80%) were Asian, 6 (12%) Caucasian/European, 1 (2%) African/Afro-American, 1 (2%) Pacific Islander and 2 (4%) Other. Athletes' sport disciplines classified according to the Sports Cardiology Section of EAPC (Pelliccia et al., 2019) were as follows: 35 mixed, 8 endurance and 6 skilled. Cardea and CON flagged 24% (12/49) and 39% (19/49), respectively, for clinician review. Except for QRS axis (in degrees) ( $r=0.31$ ,  $P<0.05$ ), there was a strong, positive correlation between Cardea and CON in measuring heart rate ( $r=0.93$ ,  $P<0.0001$ ), PR interval ( $r=0.84$ ,  $P<0.0001$ ), QRS duration ( $r=0.91$ ,  $P<0.0001$ ), uncorrected QT ( $r=0.94$ ,  $P<0.0001$ ), QTc ( $r=0.82$ ,  $P<0.0001$ ), P axis, ( $r=0.87$ ,  $P<0.0001$ ) and T axis ( $r=0.97$ ,  $P<0.0001$ ). Of note, the standard deviation of the differences in QRS axis measured by Cardea and CON was estimated to be 35 degrees. Bland-Altman plot revealed limited but varying levels of systematic biases in QRS duration, uncorrected QT, QTc, QRS axis and T axis.

#### CONCLUSION:

In this elite athlete population, there is good overall correlation and agreement in machine-reported basic ECG data between Cardea and CON, except QRS axis determination. The weak correlation in QRS axis between Cardea and CON may be of diagnostic importance (e.g. axis deviation) and potentially lead to over-/under-calls or inaccurate interpretation, warranting further investigation.

### VELOCITY OF DESCENT UNDER THE BARBELL DURING THE SNATCH IN YOUNG ELITE ATHLETES: A PILOT STUDY

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#### INTRODUCTION:

Researchers and coaches identify the "Turnover under the barbell" as a critical phase for the Snatch exercise [1]. Increasing the barbell weight results in a decrease in vertical velocity and maximum height of the barbell [2]. Therefore, the athlete needs to descend faster under the barbell in order to efficiently complete the lift. Hadi et al. [2] calculated the negative velocity of the athletes during the turnover phase of the snatch, at different percentages of load using laboratory equipment, that is unpractical to be used during training. The aim of the present pilot study was to monitor the velocity of descent of the athlete under the barbell during a simulated competition in elite athletes.

#### METHODS:

Thirteen young elite male weightlifters (G1) of different weight categories of the Italian national team (age:  $19.4 \pm 2.63$  yrs, bw:  $72.46 \pm 15.62$  kg) were tested during a simulated competition organized by the coach to select athletes that would compete in the Mediterranean Games (Tarragona 2018). For our analysis we considered the best lift (1RM) and the previous correct lift (mean:  $95 \pm 0.58\%$  of 1RM). A subgroup of 5 athletes (G2) was also tested during training at 80% of 1RM. We applied a visible marker on the coccyx of each athlete. A camera (Jeemak 4k, 120fps) was placed behind the competition platform. By analyzing the marker's trajectory (KINOVEA) we were able to calculate the athlete's velocity of descent during the turnover under the barbell. All data were tested for normal distribution using a Shapiro-Wilk test. Independent T-Test was used to compare velocity of G1. ANOVA one-way was used to compare velocity of G2. Pearson's correlation was conducted to assess the relationship between the increase in loads and the increase of athletes' velocity in G2.

#### RESULTS:



Mean velocity of G1:  $-2,98 \pm 0,28 \text{ m}\cdot\text{s}^{-1}$  (95% of 1RM),  $-3,06 \pm 0,29 \text{ m}\cdot\text{s}^{-1}$  (100% of 1RM), but the difference between the two was not significant ( $p=0,664$ ). Mean velocity of G2:  $-2,83 \pm 0,27 \text{ m}\cdot\text{s}^{-1}$  (80% of 1RM),  $-3,03 \pm 0,33 \text{ m}\cdot\text{s}^{-1}$  (95% of 1RM),  $-3,14 \pm 0,38 \text{ m}\cdot\text{s}^{-1}$  (100% of 1RM), however the difference was not significant ( $p=0,378$ ). An increase of the barbell's weight was correlated with an increase of the athletes' negative velocity between 80 and 95% ( $p<0,05$ ), 80 and 100% ( $p<0,05$ ), but not between 95 and 100% of 1 RM ( $p=0,491$ ).

**CONCLUSION:**

The results obtained are in accordance with Hadi et al. [2]. This pilot study on young elite weightlifters shows a simple method that coaches can use to quantify the velocity of their athletes even when they do not have laboratory equipment available and confirming that the athlete needs to descend faster under the barbell with increasing loads.

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**KINEMATIC DIFFERENCES BETWEEN TRANSITION RUNNING AND ISOLATED RUNNING IN TRIATHLETES – A FREE-LIVING APPROACH USING INERTIAL MOTION CAPTURE**

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**INTRODUCTION:**

Triathletes keep complaining about perceived incoordination in the early phase of the running session after transitioning from cycling to running. To date no evidence on kinematics in free-living environment has been published.

**METHODS:**

14 healthy male triathletes ( $32.2 \pm 6.3$  years) who trained to complete the ironman (IM) distance sub 9:30h in the 2019 season volunteered in this study. Kinematic data was obtained using the inertial motion capture system MVN Link by Xsens (240Hz) at a flat paved way alongside the river Main in Frankfurt (Germany; part of the track at the IM European Championship). Subjects ran in their planned competition speed ( $13.4 \pm 0.7 \text{ km/h}$ ), which was set by a cyclist (speedometer), riding in front of the athlete (slipstream). After a 10min warm-up run, an isolated run (IR) was recorded (2km). Then, athletes cycled for 90min (competition intensity/aero position) on their own bike (stationary trainer), before the transition run (TR) was recorded (3km). The analysis was performed using MatlabR2019a including angles of the back, hips, knees and ankles of both legs, each in all three degrees of freedom. In order to structure the data in active leg (AL) cycles (touching the ground) and passive leg cycles (swinging leg), the angles of the left leg were mirrored. Data were time-normalized (100 points). When the running speed reached mean speed-2SD, the first 44 steps were included in mean cycles in each run. Statistical parametrical mapping (SPM) was performed on complete step cycles to show differences between the first intervals of IR and TR via a two sided t-test ( $\alpha=5\%$ ). First, the average of all athletes was tested and secondly an individual analysis for each subject was conducted. In each individual analysis, the deviation of TR from IR was examined for all three degrees of freedom (e.g. no deviation/more flexion/extension). When comparing the individual analyses, those joints were detected in which the TR deviated in the same direction from the IR in >50% of the subjects. In these joints, the angular values ( $^{\circ}$ ) of IR and TR were recorded at the relative time-points in the step cycle showing the greatest significant difference.

**RESULTS:**

Testing overall athletes revealed no significant differences. Based on the individual analyses, 8 athletes (57,1%) experienced a similar pattern. In TR, these subjects showed more extension in the spine (min:  $1.2^{\circ}$ ; max:  $8.5^{\circ}$ ), more internal rotation in the AL hip ( $0.7-5.1^{\circ}$ ) and more supination in the AL ankle ( $1.6-4.9^{\circ}$ ). The relative time-point in the step cycle at which the difference occurred varied between the athletes (back: 20-60%; hip: 21-87%; ankle: 18-99%).

**CONCLUSION:**

Athletes running pattern are very individual, and therefore no consistent transitioning effect could be found by comparing the starts of IR and TR. However, similar tendencies in TR pattern were found in the majority of the subjects. Further analysis on the bike kinematics is needed, in order to better understand the movement pattern of TR.

**USAGE PREFERENCES IN A HEALTH APP TO INCREASE PHYSICAL ACTIVITY WITHIN FAMILIES**

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**INTRODUCTION:**

Three quarters of men and four fifths of women are insufficiently active according to the WHO recommendation [1]. In childhood, one potentially influencing factor on physical activity (PA) behavior is set by the family (e.g. by the parents behaviour). In addition to the role model function of the parents, the willingness to change behaviour and increase motivation are also required to achieve the current WHO recommendations and establish a sustainable PA level [2]. Low-threshold services in the course of digitalisation [3] offer a supportive option. These can facilitate access to a healthy lifestyle and should help users to achieve their goals. This study examines respondents preferences for a family health application to increase PA and how preferences differ between respondents who meet WHO criteria for exercise and those who do not.

**METHODS:**

The cross-sectional study involved 1008 adults from a German health insurance company who have at least one child aged 8-16 years. The online survey lasted about 30 minutes. It included a survey on health potentials and deficits in the area of PA (including the fulfilment of WHO criteria). Furthermore, questions on essential content, the evaluation of efficiency and views on useful functions and elements of a health and fitness app were given in order to create a basis for the concept development. The statistic was conducted using chi-square test and mean comparisons with IBM SPSS Statistics.

**RESULTS:**

62.5% of those surveyed wanted to use the app together as a family. The results showed that the use of apps over a period of 12 months or longer and less than three months is preferred. In addition, adults would use a health app with a focus on exercise for up to two hours per week, which corresponded to the duration of use by children (< up to 3 hours). With regard to the use of the app in one session, a duration of 4-14 minutes was preferred. Respondents who did not meet the WHO criteria asked for a medium-term use of the app based on the month ( $\chi^2=17.05$ ;  $p=.002$ ;  $C=.133$ ) and a shorter use of the app per week compared to respondents who met the WHO criteria ( $\chi^2=10.68$ ;  $p=.014$ ;  $C=.106$ ).

**CONCLUSION:**

The present study shows that there is a familial interest in a health application to increase PA. The results between the interviewees (WHO criteria met/not met) show that in order to reach those who do not currently meet the WHO criteria, it is necessary to keep the duration of use of an app with appropriate content low. It remains to be clarified how many of the respondents were experienced users of an app and whether they are currently mainly used by those who meet the WHO criteria, which could lead to different usage preferences in both groups.

## References

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### **INFLUENCE OF THE GOAL ANTI-OVERTURN SYSTEM TO AVOID ACCIDENTS USING VIDEO ANALYSIS IN HANDBALL. 2019 SANTANDER 4 NATIONS INTERNATIONAL HANDBALL TOURNAMENT.**

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Influence of the goal anti-overturn system to avoid accidents using video analysis in handball. 2019 Santander 4 Nations International Handball Tournament.

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## INTRODUCTION:

The anti-overturn system (AOS) used in the goalposts for the practice of handball is a relevant factor to avoid serious or even deadly accidents that are caused by misuse, lack of maintenance, etc. Its usage is therefore crucial for the safekeeping of this popular sport, which is played not only professionally but is one of the most popular sports in schools. Although handball rules require the goals to be attached to the sports hall floor, they are sometimes placed in different parts of the field depending on the type of training and groups that use the field at the same time, e.g. minihandball, where anchoring them is not possible. Therefore, it is useful and necessary to use alternative anti-overturn systems that guarantee the safety of users anywhere in the field, without having to anchor the goalposts.

This study shows the influence of an innovative anti-overturn system for goals called Tutigool on handball games.

## METHODS:

The free software Lince has been used for game analysis, which at the same time allows the analysis of data from the multidimensional observation proposal called the Game Action Observation System influenced by the Anti-overturn Goal System (SOAOS) composed of 9 criteria and 31 categories of all influential variables in the actions of sport.

The Anti-overturn goal System Tutigool has been used to play the 6 matches disputed in the 4 Nations International Handball Tournament. It doesn't attach the goal and allows the impact's absorption in case of a player's collision with the goal.

## RESULTS:

Goals were moved in 25.64% of the 117 body contacts that occurred during the tournament. 93.3% of those 30 movements were caused by the goalkeeper. 66.7% of the displacements occurred after the player's shot, which means 78 times and the goalkeepers body impulse on the goal was the main reason of moving the goal with 36.8% meaning 43 times.

As for the AOS influence on the game and on the players, the game was in total interrupted less than one minute in the count of the 6 matches as a result of a move of the goal, which means less than 0.27% of the 360 minutes played in the tournament. Regarding the players body contacts with the goal, there were no injuries or contusions.

## DISCUSSION:

Tutigool system does not cause any significant negative effect on the course of handball matches, while it is considered an appropriate system for the prevention of injuries. After this proposal, the International Handball Federation changed the 1:2 rule to improve handball safety.

## **CP-AP12 Statistics and analyses**

### **NEW KATA EVALUATION IN TOP-LEVEL KARATE: ANALYSIS OF FREQUENCY AND SCORE OF KATAS IN K1 PREMIERE LEAGUE**

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## INTRODUCTION:

Karate kata are executed as a specified series of a variety of moves with stepping and turning, while attempting to maintain a perfect form. With the new kata evaluation procedure created by World Karate Federation for the Olympic Games 2020, a panel formed by seven judges evaluates the kata performances and scores are given according to the technical and athletic presentation of the katas. The goal of the study is to describe the type and frequency of performed katas at the Karate 1 premiere league 2019 and to analyse if different katas have different chances of resulting successfully in top level karate competition.

## METHODS:

All performed katas during the season of Karate 1 Premiere leagues in year 2019 were recorded. Competitors' country, sex, name of the performed kata, athletic, technical and total score were recorded. Descriptive statistics, Chi-square tests and One-way ANOVA were conducted. A total of 2,190 kata were performed (1,137 in the male and 1,053 in the female category).

## RESULTS:

Number of performed katas depends on the number of entries; top-level kata medallists had to perform 5 katas. The most performed kata were Suparinpei (14.3%) followed by Anan dai (13.7%), Papuren (13.1%), Chatanyara Kushanku (9.3%) and Anan (8.5%). In general and in female category, the most successful kata in all factors (technical score  $18.67 \pm 0.69$ , athletic score  $7.90 \pm 0.36$ , and total score  $26.57 \pm 1.03$ ) was Oydomari no Passai which was not used very often (0.3%). In male category it was Kosokun Sho in total score ( $24.75 \pm 0.39$ ), Kosokun Sho in technical score ( $17.41 \pm 0.22$ ), and Sochin in athletic score ( $7.42 \pm 0.33$ ).

The most unsuccessful katas are Heiku ( $21.11 \pm 0.98$ ) in general, Kosokun Sho ( $20.47 \pm 1.46$ ) in female category and Enpi ( $20.90 \pm 1.54$ ) in male category.

There is a significant relationship between gender and choice of katas  $\chi^2 (2, N = 1,605) = 253.0, p = .00$ ). Female athletes prefer Shito ryu katas Papuren (22.5%), Suparinpei (16,0%), Anan Dai (13.8%), Chatanya Kushanku (13,2%) and Anan (8.1%), while male athletes performed Anan Dai (13.7%), Suparinpei (12.7%), Unsu (12.1%), Gojushiho Sho (9.6%) and Anan (8.9%). There was not a significant difference in score between male and female athletes (technical  $F(1)=1.71, p=0.19$ , athletic  $F(1)=2.21, p=0.13$ , total score  $F(1)=0.07, p=0.79$ ).

**CONCLUSION:**

To progress to the next round, karatekas perform longer and more complicated and complex kata. This, however, does not guarantee higher score. Shorter katas have lower score and therefore are used less. As male and female competitors choose different katas and achieve different score, training should be differentiated based on gender as well.

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**NEW PERFORMANCE INDICATORS FOR HANDBALL MATCHES: A CASE STUDY**

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**INTRODUCTION:**

Handball is one of the most popular and exciting team sports among European countries. In addition to its high physical demands, tactics execution and fast-paced play, the responses from teams to different situations and the interactions between teams are highlights in every handball match as well. Systematic game observation is an important step before analyzing game structures and sport performances. The aim of this study is to develop new handball performance indicators with a rally-based observational system in an effort to acquiring information systematically and getting more insights from matches.

**METHODS:**

The sample was the semifinal match which Germany vs. Norway from the 2019 IHF Worlds Men's Handball Championship. The video was provided by SportDeutschlandTV and was observed by using the self-designed observational system. The attributes of the observational system include the number of rallies, ball possession team, time of possession change, possession results, score type, score player type, timeout and punishments. 5 new performance indicators are proposed in this study. The offensive power shows the ratio of goals and rallies from each team, indicating if the teams seize the chance to successfully score; active defense demonstrates the possession change made by stealing balls from opponent team; active score provides ratio of normal score and total goal; and the failed attempt rate represents the numbers of unsuccessful attempts among total team rallies. Momentary strength from each team is introduced by the mean of double moving average of scoring probability.

**RESULTS:**

Norway won the semifinal match by having 31 goals (28 normal goals and 3 seven-Meter goals) within 48 rallies against 25 goals (20 normal goals and 5 seven-meter goals) within 47 rallies by Germany. The possession results show that Germany had 1 self-made error, 14 failed attempts to score and 6 ball possessions stolen by the opponent, whereas Norway had no self-made error, 13 failed attempts to score, only 2 ball possessions stolen by the opponent and 1 lost of possessions in other condition. Both teams had seven-meter ball with suspension (1 from German, 2 from Norway) as punishments, and Norway also had 2 seven-meter ball with warning. The offensive power of Germany was 0.53 and Norway 0.65. Active defense and active score were 0.04 against 0.13 and 0.8 against 0.9 by Germany and Norway respectively. The failed attempt rate from Germany was 0.30 and Norway was 0.27. Momentary strength from Germany and Norway was 0.54 and 0.63.

**CONCLUSION:**

The new performance indicators proposed in this study demonstrate higher values in the offensive power, active defense, active score, average momentary strength, and lower values in the failed attempt rate in the winning team. These indicators were all calculated from the data acquired by the self-designed and rally-based observational system in an effort to provide more insights and practical information to assist coaches and sport teams.

**IMPACT OF CONTEXTUAL FACTORS ON MATCH RUNNING PERFORMANCE IN AN ELITE SOCCER TEAM DURING A SEASON**

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**INTRODUCTION:**

Contextual factors, such as playing position, match result, opposition level are related to match physical performance as it is reflected in total distance (TD) and distances covered with various velocities (1,2). However, limited information exists on the interaction of these contextual variables on match physical performance of elite soccer players (1,3). The purpose of the present study was to investigate the main effects and interactions of playing position, match result and the opposition level on match running performance of an elite Greek soccer team during a competitive season.

**METHODS:**

Twenty-eight Greek Super League (highest level) matches played by a professional soccer team were analyzed during the 2018-2019 season using a Polar Team Pro tracking system based on GPS technology. The team finished in the 6th place of the league table. Only data for players completing entire matches were included in the analysis. Players (n=19) were assigned to one of four outfield positions [central defenders (CD); midfielders (MD); full-backs (FB) and forwards (FO)] according to their activity on the pitch. Match result (win, draw, loss) and opposition level were recorded. Opposition level was classified according to the team's final league ranking (Best teams: 1st to 5th; Middle teams: 6th to 13th; Last teams: 14th to 16th). The following match running performance measures were assessed: total distance covered (TD), high speed running distances (HSR; distance covered with more than 19 km/h), and the number of sprints (SP; more than 25 km/h).

**RESULTS:**

A significant main effect ( $F_{3,126}=35.35, p<0.001$ ) of playing position on HSR was observed. CD covered significantly ( $p<0.05$ ) less HSR and FO covered more HSR ( $p<0.01$ ) compared to other playing positions. Significant interaction effects were found on HSR and TD between playing position and opposition level ( $p<0.05$ ) and between game result and opposition level ( $p<0.05$ ). Significant interaction effects were

also found on SP between playing position and opposition level ( $p < 0.05$ ), while between game result and opposition level a tendency for significance was observed ( $p < 0.054$ ).

#### CONCLUSION:

The findings of the present study have shown that match running performance during a competitive season of an elite soccer team was interactively influenced by playing position, match result and opposition level. The observed interactions may be due to changes in the tactical behavior of players under specific circumstances (1,2). These results may be used to shed light in match physical performance in top level soccer.

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### INFLUENCE OF PERFORMANCE ACHIEVED AT EACH TRIATHLON DISCIPLINE ALONG WITH TIME OF TRANSITION PHASES ON OVERALL PERFORMANCE IN FEMALE 2006, 2007 AND 2008 WORLD CHAMPIONSHIPS

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#### INTRODUCTION:

Particular contributions of performance displayed during running [1], cycling [2] and each triathlon discipline phase [3] to overall performance have been previously studied and involve important training considerations. Accordingly, performance achieved at each discipline has a specific weight on final triathlon performance and has to be developed during the training process in a different way. Moreover, gender differences observed in the pacing behavior displayed by elite triathletes has also been previously observed [4]. Therefore, the aim of this study was to analyze the extent to which performance achieved at each discipline and both transition phases influenced overall performance during female triathlon world-class races.

#### METHODS:

Times to cover each triathlon discipline and transition phase and finishing times from 64, 60 and 51 female triathletes were collected from the open access website <https://www.triathlon.org/results> corresponding to 2006, 2007 and 2008 International Triathlon Union (ITU) World Championships, respectively.

#### RESULTS:

One-way ANOVAs found differences between championships in all phases and overall performance (swimming,  $F = 71,98$ ; transition phase 1,  $F = 87,62$ ; cycling,  $F = 327,96$ ; transition phase 2,  $F = 226,51$ ; running  $F = 23,32$ ; finishing time,  $F = 158,88$ ; always  $p < 0.01$ ). Bonferroni post hoc analyses identified differences between all championships in time to cover all phases and final performance ( $p < 0.05$ ).

Pearson correlations were conducted between phase and final times achieved at each championship. Large correlations between overall performance and performance achieved at cycling and running phases at 2006, 2007 and 2008 championships were found (2006 edition,  $r = 0.945$  and  $0.904$ , respectively; 2007 edition,  $r = 0.83$  and  $0.833$ , respectively; 2008 edition,  $r = 0.835$  and  $0.838$ , respectively; always  $p < 0.01$ ). Whereas a large correlation also was found between performance achieved during the swimming phase and final performance in 2007 ( $r = 0.596$ ,  $p < 0.01$ ), moderate correlations were found at 2006 and 2008 championships ( $r = 0.351$  and  $0.427$ , respectively,  $p < 0.01$ ). Correlations between times to cover transition phases with final performances were from moderate to large at 2006 championships ( $0.49 \leq r \leq 0.61$ ;  $p < 0.01$ ) and small at 2007 and 2008 championships ( $0.16 \leq r \leq 0.27$ ;  $p > 0.05$ ), with the exception of time to cover transition phase 1 at 2007 championships which showed a moderate correlation with performance ( $r = 0.457$ ,  $p < 0.01$ ).

#### CONCLUSION:

Final performance and performance achieved at each discipline significantly differed among 2006, 2007 and 2008 triathlon world championships in female triathletes. Performance achieved during cycling and running phases were highly correlated with overall performance. However, times to cover transition phases were not consistently correlated with final performance.

### PREDICTING 3000 STEEPLECHASE PERFORMANCE

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#### INTRODUCTION:

In middle distance track events, the prediction of performance is normally calculated from two reference distances with known time performance as follows:  $tR = [tS * (dL - dR) + tL * (dR - dS)] / (dL - dS)$  [1], where  $d/tL$ ,  $d/tR$  and  $d/tS$  are the distance/time of longer, requested and shorter reference distances, respectively. The formula was shown to be accurate to approximately 1 % or less [1]. However, this performance prediction has been used only for flat-race events, and not for calculating 3000m steeplechases (3000st) performance, where technical clearance capacities are also required. To our knowledge, scientific and systematic methods for predicting 3000st performance are lacking. Our objective was to determine and validate a method for predicting 3000st performance from two given known distances.

#### METHODS:

Data were retrieved from the world list in 3000st races [2]. For each of a total of 200 male athletes, the season best performance (SB) in 3000st, 1500m, 3000m and 5000m races were collected, from 2016 going back to their first detectable race season. Only seasons with 3000st performance were considered, for a total of 1121 performances analysed. We divided performances into 10 groups, based on 3000st SB, for time intervals of 10s, from  $<8:00\text{min}$  to  $>9:20\text{min}$ . The average performance for 1500m, 3000m and 5000m was calculated for each performance group. First, we validated the formula on our data, by comparing, for each group, the mean 3000m performance retrieved from the database, with the 3000m performances predicted for the same athletes, by using the known 1500m and 5000m races time. Then, we suitably modified the formula for predicting a distance that was equivalent to 3000st, starting from the race time of 3000st and two other reference distances and performances (new formula:  $dR = (tS * dL - tL * dS - tR * dL + tR * dS) / (tS - tL)$ ), such as 1500m and 5000m. Such analysis was performed for each group, and the relative  $dR$  was determined.

The relationship between performances was evaluated using Pearson's coefficient of correlation ( $r$ ).

#### RESULTS:

The difference between the mean 3000m performance and the predicted one was less than 1% (diff.=0.91%). The dR value for predicting 3000st performance ranged from 3058 to 3239 (mean 3137), depending on the group. Significant correlations were found between 3000st and 1500m, 3000m and 5000m times ( $r= 0.605, 0.704; 0.647$ , respectively).

CONCLUSION:

The dR mean value of 3137 could be inserted as the known distance into the formula for 3000st performance prediction, with known time performances on 1500m and 5000m races for that athlete. However, we suggest identifying the group in which the athlete belongs according to his performances in 1500m, 3000m or 5000m, and utilize the specific dR value calculated for his group.

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**THE EFFECT OF PLAYING THREE CONSECUTIVE MATCHES WITH EXTRA TIME IN RELATION TO THE FINAL. A CASE STUDY OF CROATIAN PLAYERS AT THE 2018 FOOTBALL MEN'S WORLD CUP**

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INTRODUCTION:

From 1986 to 2014, 35% of the mens FIFA World Cup matches (including the last three finals) required extra time (ET) and thus, the analysis of ET and its effect on subsequent matches is particularly important. Players taking part in the World Cups and continental championships (European Championships, Copa America, African Cup of Nations, etc.) are significantly exposed to the maximum exhaustion of energy resources – especially when they have to play an additional 30 minutes (Ekstrand et al., 2004; Arruda et al., 2015; Lago-Peñas et al., 2015). Therefore, the aim of this study was to ascertain and analyse the effect of three consecutive matches with extra time on the physical activity of the selected Croatian players in the final match.

METHODS:

The sample consisted of the 4 players on the Croatian national team (16 observations) who played for entire matches, up to 90 min, and the entire extra time period (i.e. totaling 120 mins per match) in three consecutive matches in the knockout stage and the entire 90 min of the final at the 2018 World Cup held in Russia. The analysis was conducted using data collected by an advanced motion analysis system known as STATS®. The consecutive full time matches (90 minutes) and extra times (30 minutes) were compared. The selected physical activity parameters analysed included: total distance, distance covered with an intensity of 20-25 km/h and above 25 km/h, and number of sprints.

RESULTS:

The analysis of changes between semi-final and final match showed that the biggest difference up to 90 minutes was recorded in the total distance covered (-6%) and also reached the lowest level in comparison to the another rounds of the knockout phase (respectively  $9623 \pm 793$  vs  $9052 \pm 523$  m). In turn of the three consecutive extra time periods were observed that the distance covered with intensities of 20-25km/h and above 25 km/h and the number of sprints were at least twice as low in the round of sixteen than they were in the semi-final (e. g  $5 \pm 1$  vs  $10 \pm 2$  sprints).

CONCLUSION:

The effect of three matches with extra time on the physical activity of selected Croatias players in the 90 minutes of the final match show that every analysed parameter decreased from their peak in the semi-final. Players from the Croatian national team which played in every knockout phase game during the World Cup in Russia had improve physical activity during subsequent extra times. To summarise, this investigation shows that the recovery methods of professional players playing in central positions allowed them to maintain high intensity throughout the knockout stage of the tournament.

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**DATA-DRIVEN TEAM RANKING AND MATCH PERFORMANCE ANALYSIS IN CHINESE FOOTBALL SUPER LEAGUE**

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INTRODUCTION:

Recent years have seen an increasing body of research into match performance of Chinese Football Association Super League (CSL)—one of the Asian top football leagues that have a large-scale development in standardization under the globalization of professional football. Although there have been some attempts to describe the technical-tactical and physical demands of CSL games, data-driven evaluation of team performance and league competitiveness is relatively limited. Therefore, the study was aimed to apply a state-of-the-art algorithm to the ranking of CSL teams and exploitation of key performance features in relation to match outcome based on massive match dataset.

METHODS:

Data of all 1200 matches from 2014-2018 CSL where 22 teams competed were provided by validated Champion Tracking system, producing a total of 120 match performance features related to shooting, passing, organizing, defending and goalkeeping. All features adjusted to per 50% of ball possession of the own team or the opposition team accordingly. To rank the teams by their performance and analyze the features that influence most match outcome (win/not win), a Linear Support Vector Classifier (LSVC) model was built, with the dataset being divided into a ratio of 4:1 to train and validate the model. The cost parameters that had the maximum average accuracy were selected with a 5-fold cross-validation. A one-way ANOVA was used to determine the differences in match performance among three match outcomes (win, loss and draw).

RESULTS:

The results showed that there was no difference between the team ranks of the top-4 teams and their real final league rankings, while the team ranks of other teams were similar but not as exactly the same as real rankings. The LSVC model accuracy is 0.85, and by ranking the features' weights, it was shown that the top-5 positive features were saves, shots on target in box, middle penetration shots on target,

clearances, and transition pass success. The top-5 negative features were opponent shots on target, crosses, possession midfield%, break dribble and pass success in defensive third. There were significant differences in those performance features between different match outcomes ( $p < 0.05$ ).

#### CONCLUSION:

The study revealed that the winning teams tended to perform more saves, shots on target, clearances, successful transitions, break-throughs and interceptions. On the contrary, although drawing and losing teams had more crosses, possessions in midfield, break dribbles and successful passes in defensive third, it turned out that shots and accurate attacking passes in the attacking area and saves and clearances in the defensive area had positive effects on winning. Meanwhile, it is also implied that in CSL, good performance does not always guarantee the winning of game, but high-ranked teams could always maintain better performance than their counterparts. Knowledge gained from the study would be helpful for reconsidering match styles and teams' training planning and match tactics.

### **INFLUENCE OF PERFORMANCE ACHIEVED AT EACH TRIATHLON DISCIPLINE ALONG WITH TIME OF TRANSITION PHASES ON OVERALL PERFORMANCE IN MALE 2006, 2007 AND 2008 WORLD CHAMPIONSHIPS**

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#### INTRODUCTION:

The partial contribution to overall performance of performance achieved at each of the disciplines comprising a triathlon race (swimming, cycling and running) has been previously studied [1]. However, the time covered during transition phases may also influence overall performance in triathlon in a certain manner. Therefore, the aim of this study was to analyze the extent to which performance achieved at each discipline and both transition phases influenced overall performance during male triathlon world-class races.

#### METHODS:

Time to cover each triathlon discipline and transition phase and finishing times from 68, 66 and 71 male triathletes were collected from the open access website <https://www.triathlon.org/results> corresponding to 2006, 2007 and 2008 International Triathlon Union World Championships, respectively.

#### RESULTS:

One-way ANOVAs found differences between championships in all phases and overall performance (swimming,  $F = 417.20$ ; transition phase 1,  $F = 108.43$ ; cycling,  $F = 389.23$ ; transition phase 2,  $F = 361.16$ ; running  $F = 24.07$ ; finishing time,  $F = 203.76$ ; always  $p < 0.01$ ). Bonferroni post hoc analyses identified differences between all championships in time to cover all phases and final performance ( $p < 0.05$ ).

Pearson correlations were conducted between phase and final times achieved at each championship. Large correlations between overall performance and performance achieved at cycling and running phases at 2006, 2007 and 2008 championships were found (2006 edition,  $r = 0.902$  and  $0.803$ , respectively; 2007 edition,  $r = 0.753$  and  $0.884$ , respectively; 2008 edition,  $r = 0.857$  and  $0.782$ , respectively; always  $p < 0.01$ ). Whereas a large correlation also was found between performance achieved during the swimming phase and final performance in 2008 championships ( $r = 0.703$ ,  $p < 0.01$ ), moderate correlations were found at 2006 and 2007 championships ( $r = 0.459$  and  $0.458$ , respectively,  $p < 0.01$ ). Whilst times to cover transition phases 1 and 2 always displayed small or trivial correlations with overall performance at 2007 and 2008 championships ( $0.16 \leq r \leq 0.28$ ;  $p < 0.05$  in transition phase 1 and  $> 0.05$  in transition phase 2), they showed moderate correlations with performance at 2006 championships ( $r = 0.433$  and  $0.486$ , respectively,  $p < 0.01$ ).

#### CONCLUSION:

Despite of the fact that discipline performances between the three triathlon world championships were different, achieving a high performance at each discipline was relevant in order to achieve a high overall performance. Nonetheless, performance achieved at cycling and running phases displayed larger correlations with final performance than those displayed by performance at swimming phase. By contrast to discipline phases, time to cover transition phases was not correlated to overall performance to the same extent as discipline performance was as was also previously found [2].

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2. Ofoghi et al, (2016)

### **HOW DOES BALL POSSESSION AFFECT THE DISTANCE THAT SOCCER TEAMS RUN DURING MATCHES?**

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#### INTRODUCTION:

Soccer is a highly complex sport that incorporates the interaction of physical, technical and tactical factors (Bradley, Lago-Peñas, Rey, & Gómez Diaz, 2013). Due to the complex nature of football, studies focus on the interaction between physical and technical parameters and success. The aim of this study was to verify how the ball possession affects the efforts made during the during official matches at different ranges of intensity from a multilevel perspective.

#### METHODS:

We analyzed 27 professional soccer teams that competed in the Spanish first division (LaLiga) during the 2015/16, 16/17, 17/18 and 18/19 seasons. 3040 games played and a total of 2950 games were included. The physical performance were obtained by Mediacoach.. Four physical variables were recorded: 1) total distance covered (TD); 2) total distance covered at 14 - 21 km / h; 3) total distance covered at 21- 24 km / h; 4) total distance covered at more than 24km / h. In addition, the "percentage of Ball Possession" was registred. Statistical program SPSS 25.0 was used and a multilevel analysis was performed through mixed models.

#### RESULTS:

The results show that the estimated means of the distances decrease as the speed increases, so it is established that as team have more possession of the ball they run less. However, when the other effects are included does not happen in each one of them. It can be observed that as the possession increases, are runned 113.32 m less in terms of total distance. The same happens with the distances traveled 14 - 21 km/h and 21 - 24 km/h, however, with the distance traveled > 24km/h an opposite effect occurs, 3.82 m more are run while the more possession a team has, in general throughout the season. Therefore, it can be said that as a team moves away from its average possession in a match, it runs more, specifically, 37.95 m more in the total distance traveled, 22.16 m more in the distance traveled 14 - 21km/h, 4.52 meters more in the distance traveled 21 - 24 km/h and 2.13 m more in the distance traveled > 24km/h.

#### CONCLUSION:

It has been proven teams that have a higher level of possession, both during the season and in their matches, run less, so this makes us think that we should orient the training tasks to situations that represent the physical and technical tactical demands necessary that the game will demand. Same happens in the distances traveled at 14 - 21 km / h and 21 - 24 km / h. However, taking into account the distances covered > 24 km/h, it has been observed teams that have higher levels of possession perform more meters at this speed. In addition, the result against may be a possible consequence of having more ball possession, which causes us to have the ball and propose more to overcome the game, so being prepared to carry out defensive transitions if we risk can help us that the players obtain success and support the rhythm of the match.

### **ANALYSIS OF HIGH INTENSITY RUNNING DURING GAMES IN COLLEGIATE FEMALE SOCCER PLAYERS**

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#### **INTRODUCTION:**

Global positioning system (GPS) can track player's various physical activities in soccer. In recently, total distance decreased and high intensity running (HIR) increased 1). So HIR is one of the most important activities in a game to make the difference between winning or losing. However, we can't analyze the situation when athletes perform HIR in a game only using GPS devices. If we can find the situations, it's helpful information for coaches. Especially, there are few researches like this in Japanese female soccer players. The aim of this study was to analyze the situations when high intensity running (HIR :  $\geq 21$ km/h) was performed during soccer games in collegiate female soccer players.

#### **METHODS:**

Eighteen college female soccer players (age :  $20.3 \pm 1.29$ , height :  $161.1 \pm 5.65$  cm, weight :  $55.6 \pm 6.24$  kg) equipped with GPS (10Hz) during 8 official games (excluding goal keepers). They were categorized 5 positions: (forward : FW, side midfielder : SMF, central midfielder : CMF, side back : SB, center back : CB). All games were video filmed to record the analysis of the situations when HIR using a broad video camera. The videos linked GPS data with the dedicated analysis software and extracted the videos when the HIR was performed. They were categorized 4 patterns : a) which team possess the ball when the HIR was performed (Possession or Without Possession), b) what type of the movement of the HIR (Start Moving : MOV, Chasing : CHA and ETC), c) the direction of the HIR (Forward, Backward, Right, Left, Diagonally Right Forward, Diagonally Left Forward, Diagonally Right Backward, Diagonally Left Backward Sprint), d) where the HIR was performed (Attacking third, Middle third, Defending third).

#### **RESULTS:**

For the number of sprints, defensive positions such as FW and were required more than offensive such as SMF CMF, SB and CB, suggesting that the number of sprints has different characteristics between positions. The distance per sprint has not different characteristics between positions. However, as for the phase of movement when the player performed the sprint, the phase of chasing the ball and the opponent was longer than the phase of start moving. The maximum speed has not different characteristics between positions. However, maximum speed in the phase of movement when the player performed the sprint was faster than any other situations.

#### **CONCLUSION:**

Our results suggested that the situation in HIR during a game is different depending on the position and the situation of the game in terms of frequency and maximum speed among college female soccer players, and the distance of HIR varies depending on the game situation.

### **RELATIONSHIPS BETWEEN COURT SURFACES, RISK OF INJURIES, GENDER AND PLAYING STANDARDS IN TENNIS**

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#### **INTRODUCTION:**

Injuries are part of all professional or amateur players' career who have to perform several tournaments on different "fast" (i.e., grass, carpet and hard courts) or "slow" surfaces (i.e., clay courts). Several factors such as congested calendar, travel and jet lag, match duration and/or varying court surface have been proposed. However, no study has yet investigated the associations between court surfaces and tennis injury in reference to playing standards and gender from the "Open" era (mid-sixties) until today.

#### **METHODS:**

Data were collected from all Association of Tennis Professionals (ATP), Women Tennis Association (WTA), Challenger and Future circuits' matches played between 1969 and 2018. Defaults, withdrawals, walkovers and retirements of men and women players have been identified considering the court surfaces (i.e., grass, carpet, hard and clay courts). A binomial logistic regression model was used to assess the differences between the various explanatory variables and their influence in reference to court surface, gender and playing standard.

#### **RESULTS:**

Results reveal that the probability of injury significantly increased on "slow" surfaces compared to "fast" surfaces (odds ratio (OR) = 1.03, 95% confidence interval (CI), 1.01-1.05,  $P = 0.001$ ). The highest probability of injury was found for Future and Challenger circuits (+5.1% and +4.5%, respectively), whereas ATP/WTA circuits demonstrated the lowest probability of injury (+3.6%). Results also show that men were 1.2 times more likely to sustain an injury risk than women.

#### **CONCLUSION:**

Results indicate different risk of injury depending of playing standards and gender, with a higher likelihood of injury on "slow" vs. "fast" surfaces for Future and Challenger circuits, and men sustaining injury 1.2 times more likely than women. This suggests that different injury prevention strategies should be applied for different surfaces, gender and playing standards.

### **BIOMECHANICAL ANALYSIS OF THE WOMEN'S 400 M HURDLES AT THE IAAF WORLD ATHLETICS CHAMPIONSHIPS DOHA 2019: RHYTHMIC STRUCTURE AND EFFORT DISTRIBUTION.**

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#### **INTRODUCTION:**

The first documented 400 m hurdles race for women took place in 1971 and the

IAAF (now World Athletics) officially recognised the event in 1974. Since then, some competitions of women's 400 m hurdles have been analysed. However, the 400 m hurdles race is an athletic discipline rarely subjected to official individual biomechanical study at World Championships or Olympic Games (1).

**METHODS:**

The rhythmic structure and effort distribution of the nine women's 400m hurdles races of the IAAF World Athletics Championships Doha 2019 have been analysed: 5 heats (35 athletes), 3 semi-finals (24 athletes) and 1 final (8 athletes). Thus, 67 individual performances have been analysed, including that of champion Dalilah Muhammad, who broke the world record with 52.16 sec. 87 variables of each athlete by race were analysed, 19 qualitative and 68 quantitative (including spatial, temporal and spatio-temporal parameters), related to the rhythmic structure and effort distribution. All races were recorded by 3 cameras (2 Casio Ex-F1 and 1 Sony A9) placed in different positions of the stand of the Khalifa Stadium, permanently recording all the participants in each race and also recording the output trigger signal. The images were analysed using Kinovea (v.0.8.15) software.

**RESULTS:**

Related to the stride patterns or rhythmic structures, uniformity is non-existent and most patterns are individual (one-person). Most of the athletes do not repeat stride patterns from one round to the next. 24 different rhythmic structures have been found in heats, 15 in the semi-finals (including 7 new ones) and 6 in the final (including 1 new one). Only one athlete of the finalists repeats rhythmic structure in the three races she disputed. Moreover, the athletes who ran the fewest steps in the total race achieved better results (Rxy .643,  $p < .001$ ). Related to the distribution of the effort, the best athletes are the ones with the lowest speed losses after the eighth hurdle, have the smallest time difference between fastest and slowest interval, and less time wasted before the change of rhythmic structure in each section. The loss of speed in the second part of the race correlates with the final time (Rxy .890,  $p < .001$  and Rxy .956,  $p < .001$  in the final), much more than in the men's races of this World Championships. A correlation curve between the time between hurdles and the final time has been found in the total of the sample, being the highest in the eighth rhythmic unit, between hurdles 8 and 9 (Rxy .807,  $p < .001$  and Rxy .904,  $p < .001$  in the final).

**CONCLUSION:**

A correct distribution of effort and a more stable rhythmic structure are determining factors to obtain the best results in the women's 400m hurdles event.

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## CP-AP13 ACL

### DIFFERENCES BETWEEN ACL-INJURED AND NON-INJURED ATHLETES IN MOTOR COORDINATION PATTERNS AND LEG LOADING AND WHEN INSTRUCTED TO PERFORM "SOFT LANDING" – A PILOT STUDY

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**INTRODUCTION:**

Rupture of the anterior crucial ligament (ACL) is a prevalent severe knee injury with long-term consequences for maximal force gain, proprioception, leg use, and re-injury risk [1,2]. These long-term effects might influence an athlete's ability to adapt or optimize motor coordination patterns according to given instructions. The current study tested the hypothesis that there are differences between ACL-injured and non-uninjured athletes in how they adapt (1) their motor coordination patterns, or (2) their leg loading, when instructed to land "softly" compared to normal landing.

**METHODS:**

Fourteen athletes (mean age 24y; 3 ACL-injured + 3 non-injured females and 4+4 males; ACL-rupture at least 18 months ago) performed a distant landing from a 40cm box onto two force plates (3000Hz) for the right and left foot. The athletes' motion was tracked through 43 markers distributed over all body segments and recoded with 8 infrared cameras (Vicon, 200Hz). Participants performed 5 trials of normal landing and were then instructed to land "softly" for another 5 trials. Motor coordination patterns were determined through a principal component analysis performed on the marker trajectories (first 500ms of ground contact) [3,4]. Leg loading was assessed by determining the peak forces within the first 100ms, normalized to body weight. Repeated measures ANOVAs were conducted ( $\alpha = 5\%$ ; effect size  $ES = \text{partial } \eta^2$ ) to detect effects of instruction (normal, soft), group (injured, non-injured) and interactions.

**RESULTS:**

Motor coordination patterns showed clear differences between instructions ( $p = .009$ ,  $ES = .45$ ) while an interaction effect suggested deviating changes in different coordination patterns ( $p = .036$ ,  $ES = .56$ ). However, effects of injury group or interaction effects with group were non-significant. Vertical as well as medio-lateral peak forces declined in soft landing ( $p < .001$ ,  $ES = .91$  and  $p = .001$ ,  $ES = .63$  respectively). In medio-lateral and anterior-posterior peak forces a trend for an interaction between injury group and instruction was observed ( $p = .095$ ,  $ES = .22$  and  $p = .096$ ,  $ES = .21$ , respectively).

**CONCLUSION:**

While the instruction to land softly caused clear changes in motor coordination patterns, differences between injury groups were not detectable. However, horizontal peak forces did suggest (statistical trend, large ES) deviating adaptations between how the groups adjusted to the instruction.

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## BIOMECHANICAL ASSESSMENT FOR THE RETURN TO SPORT AFTER ACL INJURY: WEARABLE INERTIAL SENSORS VS MARKER-BASED MOTION CAPTURE

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### INTRODUCTION:

In return to sport training programmes after Anterior Cruciate Ligament (ACL) injury, biomechanical assessment is crucial to understand whether an athlete is ready to come back or not. Motion capture is oftener used to identify dangerous patterns that could lead to re-injury and further stops. Moreover, recent studies underlined the need for multi-joint biomechanical evaluations performed directly on field. Even though optoelectronic marker-based (OMB) motion capture is the gold standard, it is highly bonded to Lab contexts. Wearable inertial sensors (WIS), rather, are easily transportable and usable outdoor. Nevertheless, the accuracy of WIS has not been proved yet for high-speed and high-impact movements, thus the ones performed in real trainings and matches. The aim of the present work was to validate the WIS against the OMB motion capture in a training programme specifically developed for the return to sport assessment after ACL injury.

### METHODS:

Thirty-four healthy athletes from different sports (23±4 years, 18 male and 14 female, Tegner Level 9) were enrolled. Every athlete performed a specific test based on six motor tasks: single-leg squat (SLS), drop jump (DJ), lateral landing (LL), frontal deceleration (DEC), single leg hop (SLH), change of direction (CD). Three valid repetitions per leg of every task were performed. Motion data were collected simultaneously with OMB (Vicon) and WIS (Xsens): OMB included 42 retroreflective markers placed according to the Plug-in-Gait model; WIS set included 15 inertial sensors (full body configuration). Kinematic data of ankle, knee, hip, pelvis, and trunk joints were collected. The accuracy of the WIS against the gold standard OMB was assessed using correlation coefficients ( $r$ , CMC) and absolute or normalized error measurements (Root Mean Square, Range of Motion Error, Mean Relative Variability).

### RESULTS:

A total of 880 valid trials were compared between the systems. The accuracy of the WIS was excellent for all the joint angles on the sagittal plane in all the six movements performed ( $r > 0.95$ ,  $p < 0.0001$ ), error measures were always below 3°. On frontal plane, correlation was good-to-excellent for all the repetitions of the entire test ( $r: 0.53-0.92$ ,  $p < 0.01$ ); errors were slightly higher for the high-speed movements (CD, DEC 3-6°) compared to the slower ones (SLS, DJ 1-4°). On the transverse plane, errors were generally higher (up to 8°), particularly for knee and pelvis joints.

### CONCLUSION:

The WIS showed a very good overall accuracy compared to the gold standard OMB in the evaluation of the athletes' biomechanics. High dynamics of movements did not significantly affect accuracy, thus endorsing the use of WIS for return to sport assessment after ACL injury. Light incongruences were found regarding the transverse plane angles. WIS represents a valuable alternative to OMB motion capture: although some accuracy adjustments are needed, this technology could pave the way to on-field quantitative assessment of ACL injury risks.

## FATIGUE INDUCED BY REPEATED TURNS PRODUCES KINEMATIC CHANGES IN FEMALE SOCCER PLAYERS

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### INTRODUCTION:

The incidence of Anterior Cruciate Ligament (ACL) injury in female athletes is still remarkable (1). In particular, soccer has one of the highest ACL frequency and female athletes are 2 to 3 times more likely to get injured than men (1). Nearly 80% of all ACL injuries are due to non-contact mechanism and occur during landing, pivoting or cutting maneuvers (2). ACL injury is multifactorial, but modifiable risk factors may include abnormal cutting patterns due to fatigue (3,4). However, the extent to which fatigue alters movement mechanics is still unclear (4,5). A better understanding of the influence of fatigue on these mechanisms would enhance the development of prevention programs.

### METHODS:

Nine elite female soccer players (age: 20-31 years, BMI: 18.4-22.7 kg m<sup>-2</sup>) playing in the first or second Italian division ("Serie A" and "B") performed a 5-m shuttle-run test until exhaustion, paced at 70% of their maximal aerobic speed (2.6±0.2 m s<sup>-1</sup>). The three-dimensional position of 37 reflective markers during the test was obtained with an optoelectronic motion analysis system (BTS, Italy). Peak blood lactate concentration was measured at the end of the test. A biomechanical model was developed in Visual 3D (C-Motion, USA) to obtain hip, knee and ankle 3D kinematics. Statistical parametric mapping (paired t-tests) were used to compare joint kinematics during the stance phase between the turns 6-10 and the last 5 turns executed with the preferred leg.

### RESULTS:

The post-exercise peak of blood lactate concentration was 10.7±3.0 mM. The hip was more extended at mid-stance ( $t=2.398$ ,  $p=0.038$ ), as well as the knee ( $t=2.635$ ,  $p=0.005$ ). The tibia was more internally rotated from 20% to 80% of the stance phase ( $t=2.677$ ,  $p<0.001$ ). No significant differences were observed for the ankle joint.

### CONCLUSION:

Results highlighted a sequence of movement alterations related to biomechanical risk factors for ACL injury (2). Knee and hip flexion were reduced, while we observed an increased tibial internal rotation and knee dynamic valgus. No alterations occurred in knee kinematics on the frontal plane: likely, the difference between the fresh and the fatigued condition was not sufficiently demanding to cause this pattern alteration. However, the baseline value (10-15 degrees of knee abduction) could be potentially hazardous per se, even before the onset of fatigue.

Following the findings of our recent work on male athletes (3), it is confirmed that fatigue can be a part of the multifactorial scenario in which ACL injuries occur. Given also the higher incidence in women, the implementation of specific neuromuscular training when players are fatigued can provide significant benefits, moderating modifiable biomechanical risk factors.

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## CP-AP14 Military / Occupational physical activity

### PARATROOPERS' OPERATIONAL FITNESS

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#### INTRODUCTION:

This study evaluates the impact of a new physical training practice on injuries in paratroopers. Whereas the optimization of the paratroopers' physical fitness responds to operational efficiency and to the application of new doctrines (CNSD, 2011), the various parachute jumping techniques have created strong physical and technical constraints which could result in different types of accidents and injuries (Lafourcade et al., 2018).

#### METHODS:

After acquiring data of sports practices and effects paratroopers' training, measures were implemented as part of a « renovated physical », military and sports training procedure (7 hours per week). Health data were collected from 117 soldiers (age: 25±4 years-old, BMI = 24±2 kg/m<sup>2</sup>) and analyzed by a physiotherapist and medical students.

#### RESULTS:

The renovated fitness system allows a marked improvement in sports-related pathologies. The rate of injuries related to physical activities decreased from 65% to 22% in the first-year follow-up. Diseases due to hyper-solicitation, which accounted for 40% of injuries, fell to 1%. The risk of injury after 1-year follow-up decreased from 48% to 16%.

#### CONCLUSION:

The practice of an adapted training must therefore be popularized, as well as the reduction of the weekly mileage running, in accordance with Ressort et al. (2013). Overall, the diversification and personalization of training must be the focus of attention in order to achieve a modernization of physical, military and sports training. The intervention was highly successful in reducing injury rates. However, preventive measures must also be considered individually in order to reduce the risk as much as possible. Operational relevance: Reducing injuries makes soldiers more available and military units more operationally effective.

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### MUSCLE STRENGTH OF YOUNG MALE AND FEMALE ADULTS: DIFFERENCES BETWEEN PHYSICALLY INACTIVE AND ACTIVE PERSONS IN MAXIMAL FORCES OF KNEE EXTENSORS, TRUNK FLEXORS AND EXTENSORS, ARM FLEXORS AND HANDGRIP

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#### INTRODUCTION:

Muscle strength is an important factor for health, sports performance, and occupational aptitude for physically demanding jobs like fire-fighting, police or the military. Meeting these demands with adequate strength may already be a problem for young males. Females are further disadvantaged due to well-known sex-related differences [1]. Our aim was to determine maximal isometric strength differences between sexes in inactive (INACT) and active (ACT) groups. With respect to occupational aptitude, we measured strength of knee-extensors (KE), trunk flexors (TF), and -extensors (TE), arm flexors (AF) and handgrip (HG) in young adults. These data from an epidemiologically relevant sample may also serve as reference points for evaluation of fitness promotion focused on load handling tasks.

#### METHODS:

2,089 males (m) and 702 females (f) (18-25yrs) from the "Fit for life" study were included. Maximal voluntary isometric strength (Fmax) was derived from 15s force-time tracings. Sporting activity was self-reported via scaled questionnaires. Set categories "never/rarely" (INACT) and "3x and more/week" (ACT) were used to distinguish inactive from physically active participants. ANOVA was used to determine significant differences.

#### RESULTS:

Sex and activity had significant (all p<0.001) effects on Fmax in all muscle groups: (m vs f/mean±SD): 529±90 vs 334±67N(HG); 579±112 vs 382±85N(KE), 209±41 vs 108±26N(AF); 591±122 vs 361±79N(TF); 807±174 vs 514±113N(TE); (INACT vs ACT/mean±SD): 460±131 vs 489±114N(HG); 502±143 vs 541±132N(KE), 168±58 vs 192±57N(AF); 489±151 vs 552±146N(TF); 701±219 vs 748±196N(TE).

Closer inspection of the four groups (mINACT/mACT/fACT/fINACT) showed Fmax differences to vary between muscle groups: Largest Fmax differences between fINACT/fACT vs mACT were found for arm flexors (44,9%/54,3%), smallest for leg extensors (60,8%/68,1%). Corresponding values of the other muscle groups varied from 54,9% to 66,9%.

#### CONCLUSION:

The cross-sectional approach and limited information about physical activity engaged in (no content, duration, intensity) are substantial limitations, so causal relations cannot be inferred, i.e. only drawn cautiously. Nevertheless, results can serve as reference data sets for strength in young adults and its general variability in five key muscle groups relevant for sports/occupational aptitude. Inactive females produced roughly 44-61% of Fmax compared to active males. Moreover, differences persisted when comparing active females (training 3x and more/week) to inactive males: Active females reached only 58-70% of Fmax of inactive males. Largest effects of physical activity were found for arm flexors and handgrip. Findings confirm previous studies of higher risks for overload and injury for females in occupations

with heavy lifting and carrying tasks, or heavy equipment. Our results underline the necessity of tailored workplace health promotion. Strength training may reduce the force-load problem for females at work.

1 Sievert et al.(2019) 24th ECSS P.547

**DO PHYSICALLY ACTIVE NURSING STAFF DIFFER IN THEIR HR AND HRV STRESS-REACTIVITY TO NON-ACTIVE STAFF? - A PILOT STUDY**

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**INTRODUCTION:**

Regular physical activity is assumed to be associated with reduced responsiveness to psychosocial stress [1]. However, studies conducted in the setting of highly stressed occupational groups such as nursing are rare. The aim of this study is to evaluate the feasibility of a psychosocial stress test in nursing personnel and to examine the influence of regular physical activity on staff's stress reactivity.

**METHOD:**

The cross-sectional pilot study included N=12 elderly care nursing staff (age: 37.6± 9.4 years, 8 females). Demographic variables, physical activity status and perceived stress were assessed via questionnaires (Perceived Stress Scale 10 [2]). All participants were exposed to a standardized psychosocial laboratory stressor in the nursing home (Trier Social Stress Test (TSST)) [3]. Autonomic stress response (mean heart rate (HR), heart rate variability (HRV)) was repeatedly measured before, during and after stress exposure using a wireless chest heart rate transmitter (Polar RS800, Polar Electro). The analysis incorporated ANOVA with repeated measurements as well as more conservative Friedman and Wilcoxon rank-sum tests (SPSS 23, IBM).

**RESULTS:**

Mean HR (Chi2(6)= 31.31; p< 0,001) and HRV (RMSSD (Chi2(6)= 20.05; p= 0,001), SD1 (Chi2(6)= 20.05; p= 0,001)) significantly changed throughout the 6 measurements during TSST protocol. n=8 participants stated to be regularly physically active. We found no significant interaction between measurement point and physical activity for any of the stress reactivity outcomes (mean HR, RMSSD and SD1). Furthermore, no group differences at different measurement points in autonomic stress reactivity nor in perceived stress reached significance using a Wilcoxon rank-sum test.

**DISCUSSION:**

The TSST was administrable in the nursing setting and nursing staff showed significant mean HR and HRV changes during testing. Nevertheless, no significant differences between physically active and non-active nursing staff could be found in regard neither to stress reactivity nor to perceived stress. These results could indicate that prior findings on reduced responsiveness to stress in physically active participants may not be transferable to highly stressed professions such as nurses. Due to a small sample size, these results need to be evaluated in further studies.

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**LEISURE-TIME EXERCISE AT MIDDLE-AGE IS ASSOCIATED WITH MUSCLE MASS AND PHYSICAL FUNCTION IN OLDER WOMEN REGARDLESS OF PHYSICAL ACTIVITY LEVEL AT OLD AGE.**

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**INTRODUCTION:**

While physical activity (PA) during adulthood may counteract decline in muscle mass and functional capacity at old age, little is known about the impact of PA during different periods of adulthood (e.g. early and late middle-age). In addition, it is currently unknown whether PA performed during leisure-time and occupational-time induces similar effects on muscle mass and functional capacity at old age. Therefore, we examined whether leisure-time and occupational PA during middle-age are associated with muscle mass and physical functioning at old age.

**METHODS:**

Older community-dwelling women (65-70 yrs; n=117) recalled their leisure-time sport activities and occupational PA levels between ages 35 to 65 years using a validated questionnaire (HAPAQ). Participants were asked to report on activities consisting of moderate intensity or higher (≥ 3 METs) and performed at least once a week during one year. Total amount of MET-minutes during ages 35 to 50 and 50 to 65 years were summed and averaged per week. Participants accumulating at least 600 MET/Minutes were classified as physically active. Based on the reported professions, participants were classified into two categories: sedentary occupations, where participants spent most of the time sitting and manual occupations, spending most of the time standing requiring moderate to vigorous physical efforts. Present PA was measured by accelerometry (Actigraph). Physical performance was measured using a submaximal ergometer cycle test (cardiovascular fitness) and dynamometry (maximal isometric arm and leg strength). Muscle mass was assessed by bioelectrical impedance analysis (BIA) and skeletal muscle mass index (SMI) was calculated. Factorial analysis of variance (ANOVA) was employed to investigate the influence of middle-age PA behaviour on muscle mass and physical function at old age. All analysis were adjusted for present PA behaviour and level of adiposity.

**RESULTS:**

Engagement in sport-related activities during middle-age [35 to 65 years] had a beneficial effect on cardiorespiratory fitness and muscle mass at old age as women who fulfilled at least 600 MET min/week had a significantly higher VO<sub>2</sub>max (P<0.01) and SMI (P<0.05) at old age compared to those less active. Importantly, this positive remained, even when potential influences of past occupational PA and current PA level (CPM) were considered. Interestingly, these effects were driven by engagement in sport-related activities during late middle-age (50 to 65 years). Middle-age engagement in sport-related activities had no influence on maximal isometric strength in arms or legs at old age. Finally, previous type of occupation had no significant effect on either VO<sub>2</sub>max or SMI at old age.

**CONCLUSION:**

Our findings highlight the importance of engaging in regular PA of at least moderate intensity during late middle-age in order to promote muscular and functional benefits at old age. Importantly, these findings seem to occur regardless of occupation type and habitual PA level at old age.

## PROXIMITY TO NEIGHBOURHOOD AND WORKPLACE RECREATION FACILITIES DOES NOT FAVOR MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY

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### Introduction

Studies on the proximity and use of neighbourhood recreation facilities and their relationships with physical activity have yielded mixed findings. In addition, workplace recreation facilities and its association with sitting time have been rarely documented.

### Methods

Three hundred and fourteen adults aged 18 to 65 were recruited in 32 neighbourhoods in Hong Kong. Participants were asked to wear hip-mounted Actigraph accelerometers for 7 days and report the leisure-time physical activity and sitting time, the availability and proximity to neighbourhood and workplace recreation facilities, and report if they have used the recreation facilities in the past 2 months. Using published accelerometer cut-points, objectively measured physical activity was categorized as sedentary, light and moderate-to-vigorous physical activity. Generalized estimating equation accounting for clustered sampling was used to identify significant predictors of the objectively measured and self-reported physical activity.

### Results

Adjusting for socio-demographic factors, having used the closest neighbourhood recreation facilities was associated with a decrease in objectively measured time spent on sedentary activity ( $B=-20.74$ ;  $CI:-36.5, -5.0$ ;  $p<.05$ ). However, perceived shorter distance to the neighbourhood and workplace recreation facilities were associated with a decrease in objectively measured ( $B=-7.1$ ;  $CI:-14.0, -.3$ ;  $p<.05$ ) and self-reported time spent on moderate-to-vigorous physical activity ( $B=-116.0$ ;  $CI:-188.7, -43.2$ ;  $p<.05$ ) respectively. In contrast, perceived shorter distance to the neighbourhood recreation facilities was associated with a decrease in self-reported total sitting time ( $B=-41.9$ ;  $CI:-80.9, -2.8$ ;  $p<.05$ ). A couple of unexpected findings indicate that having used the workplace recreation facilities was associated with an increase in self-reported sitting time at home ( $B=31.7$ ;  $CI:4.2, 59.2$ ;  $p<.05$ ). Whilst the presence of workplace recreation facilities was associated with an increase in both self-reported sitting time at home ( $B=45.1$ ,  $CI:16.0, 74.2$ ;  $p<.05$ ) and total sitting time ( $B=55.9$ ;  $CI:17.8, 93.9$ ;  $p<.05$ ).

### Discussion

The findings of this study imply that the proximity to recreation facilities does not favor moderate-to-vigorous physical activity. While the cause is unknown, it is speculated that the reduced transport-related activity as a result of shorter traveling distance may reduce moderate-to-vigorous physical activity. However, the proximity to recreation facilities may reduce sitting time. Using workplace recreation facilities may cause extended sitting time at home due to physical exhaustion. Further investigations are needed to prove the above speculations.

## CP-BM01 Biomechanic and Human Movement Performance

### EFFECTS OF SHORT-TERM PILATES EXERCISE ON TRUNK STABILITY AND ELECTROMYOGRAPHIC ACTIVITY DURING CRISS-CROSS EXERCISE IN DIFFERENT CONDITIONS

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#### INTRODUCTION:

Pilates exercise has been widely used to strengthen trunk muscle, and to improve flexibility. A recent study reported that the total score of the functional movement screen (FMS) could be developed using Pilates exercise (1). Surface electromyography (EMG) is used in biomechanics to evaluate muscle activity during a specific exercise (2). EMG has also been used to measure trunk muscle activity during Pilates exercise (3). The primary aim of this study was to investigate whether short-term Pilates exercise improves the deep squat (DS) and the rotary stability (RS) of the FMS. A secondary aim was to compare the EMG activities of surface abdominal muscles during Pilates exercises in different conditions such as private lesson and group lesson.

#### METHODS:

Study participants were 10 college students (aged  $21.6 \pm 0.5$  years) who were categorized as follows: Pilates group (PG,  $n = 5$ ) and control group (CG,  $n = 5$ ). Participants in PG engaged in a 30-min mat Pilates exercise under the guidance of a licensed instructor once a week over a period of 5 weeks. The DS and the RS of the FMS were used to evaluate the core stability and the joint flexibility before and after this intervention. The EMG signals of the rectus abdominis and the external oblique (EO) muscles were recorded on both sides of the body during Pilates exercise (criss-cross). Root mean square values were normalized by the maximal voluntary isometric contraction method.

#### RESULTS:

No significant differences were observed in the DS and RS scores between the two groups, which might have been due to the small sample size and the short duration of the intervention. When EO muscle activation during criss-cross exercise was compared between the private lesson and group lesson, there was a statistically significant difference, suggesting that the EO muscle was more activated in the private lesson than in the group lesson ( $p < 0.05$ ). Private lesson promoted greater abdominal muscle activation than group lesson.

#### CONCLUSION:

Short-term Pilates exercise is not effective in improving or strengthening the trunk stability. In addition to the short duration of intervention in this study, group lesson was one of factors influencing the result. Private Pilates exercise provides a proper teaching technique and is effective for strengthening the core stability and flexibility.

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## THE ENERGY COST OF NON-STEADY LOCOMOTION (SPRINT AND SHUTTLES) IS NOT RELATED WITH THE ACTIVE MUSCLE VOLUME

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### INTRODUCTION:

Human non-steady locomotion (e.g. sprint and shuttle) are forms of locomotion particular importance for events like soccer, where the athletes could perform large accelerations, decelerations and changes of directions. The non-steady locomotion implies a significant increase in energy expenditure compared to running at constant-linear speed mainly because of the accelerations and decelerations phases. One possible explanation could imply the active muscles. Indeed, it is possible to assume that the larger the acceleration phase the higher the propulsive force required to propel the body and the higher EMG activity of the lower limb muscles. Therefore, the aim of this study is to investigate this research hypothesis.

### METHODS:

18 male U17 elite soccer players (mass  $64.83\text{kg}\pm 3.78$ , height  $174.72\text{cm}\pm 5.04$ , B.M.I.  $21.26\pm 1.37$ ) performed different tasks: 25m linear sprints and shuttle running over a distance of 5+5m, 10+10m, 15+15m, 20+20m. During each trial, running velocity was collected using a GPS-IMU Spinalia v2, while an Myontec M-Body 2 was used to obtain the EMG activity of the quadriceps, hamstrings and gluteus muscles. The energy cost of sprint running (SR) and shuttles were calculated as proposed by Minetti & Pavei, 2018 and Zamparo et al. (2019), respectively. Finally, the total EMG activity (EMGTOT: sum of the EMG activity of each muscle group) was calculated using the Myontec software as well as the ratio between the quadriceps and the hamstring activity (Q/H).

### RESULTS:

SR showed larger values of running velocity ( $6\pm 1$  m/s) compare with the shuttle runs at all the investigated distance. Mean value of running velocity increased as a function of shuttle distance (from 3 to 5 m/s, for 5+5 and 20+20m, respectively). The energy cost of SR ( $18.8\pm 3.7$  J/kg/m) was larger than that of shuttles (from 23 to 10 J/kg/m for 5+5 and 20+20m, respectively), except when comparing SR with shuttle at 5+5. EMGTOT was larger for SR compared with all the investigated shuttle distances. Further, no significant differences were observed among shuttles in EMGTOT. Q/H was lower for SR ( $0.80\pm 0.05$ ) compared with shuttles and decreased as a function of shuttle distance ( $1.01$  to  $0.88$  for shuttle at 5+5 and 20+20, respectively), showing linearity between Q/H and speed in shuttle runs ( $r^2=0.99$ ).

### CONCLUSION:

The EMGTOT could not explain the differences in energy cost. Indeed, whereas the energy cost of non-steady locomotion was affected by the locomotion task and by the distance covered, the EMGTOT was unaffected by the shuttle distance, suggesting that other mechanisms are involved in determining the metabolic demand during non-steady locomotion. Finally, the Q/H ratio suggests that the larger the acceleration phase the larger the role of the hamstring muscles, changes as speed increases the ratio of muscle recruitment.

## RELATIONSHIP BETWEEN THE START BACK SCREENING TOOL SCORE WITH PAIN, TRAINING LOAD AND PHYSICAL PERFORMANCE OF THE LUMBAR SPINE IN ADOLESCENTS CLASSICAL BALLET

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### INTRODUCTION:

Classical ballet adolescents perform complex joint movements, which requires load impact on the joints, lumbar spine and body balance to perform the dance. In the search for better performance, many dancers exceed the training load, which results in acute low back pain and dysfunctions and limitations in the spine movement. This can lead to the dancers withdrawal from sports practice. However, to date, there are no studies that verify the relationship between low back pain prognosis, training load and physical performance of dancers. Objective: To verify the relationship between the Start Back Screening Tool score and low back pain, training load (time and frequency) and spine flexibility in Classical Ballet adolescents.

### METHODS:

90 adolescents practicing Classical Ballet ( $15.0\pm 4.0$  years,  $52.9\pm 9.6$  kg,  $1.61\pm 0.9$  m), intermediate level, were evaluated. To check the score of the poor prognosis of low back pain, the Start Back Screening Tool (SBST) questionnaire was used. Practice time and training frequency were assessed using a questionnaire. Lumbar spine flexibility was assessed using the Shouber test and Stibor index. To assess the pain intensity, the Visual Analogue Scale (VAS) was applied. Multiple linear regression analysis was performed, considering the score from the SBST questionnaire as a predictor variable for the dependent variables analyzed, considering a 5% significance level.

### RESULTS:

There was a positive relationship between the SBST score and increased training frequency ( $r=0.38$ ,  $r^2=0.14$ ,  $t=2.5$ ,  $p=0.014$ ) and pain intensity after the dance ( $r=0.36$ ,  $r^2=0.13$ ,  $t=2.30$ ,  $p=0.027$ ). The flexibility of the lumbar spine: Shouber test ( $r=0.09$ ,  $r^2=0.08$ ,  $t=0.57$ ,  $p=0.593$ ) and the Stibor index ( $r=0.18$ ,  $r^2=0.03$ ,  $t=1.1$ ,  $p=0.272$ ), as well as the time of dance practice ( $r=0.06$ ,  $r^2=0.04$ ,  $t=0.39$ ,  $p=0.692$ ), did not present significant relations with the SBST questionnaire score.

### CONCLUSION:

The literature has shown that the increase in training frequency can be an important risk factor for lumbar spine dysfunction in classical ballet young dancers<sup>1-4</sup>. The differential of this study was to show that the Start Back Screening Tool (SBST) score was a good predictor of the increase in training frequency and pain intensity in adolescents who practice classical ballet.

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## **PELVIC AND TRUNK ROTATION HAS A KINETIC EFFECT ON SHOULDER ABDUCTION ANGLE DURING BASEBALL PITCHING: KINEMATIC STUDY FOR GROWING BASEBALL PITCHERS.**

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### **INTRODUCTION:**

During pitching motion in baseball, the kinetic energy of the lower limbs is transmitted to the upper limbs through the pelvic and trunk. An improper pitching motion disrupts this kinetic chain, resulting in shoulder and elbow injuries, especially in growing baseball pitchers. However, the precise mechanism of this chain among upper limbs and pelvic and trunk, has not been revealed. In this study, we conducted a kinetic analysis of pitching motion of growing baseball pitchers to clarify the mechanism of this kinetic chain.

### **METHODS:**

The motion capture system was applied to 32 junior high school baseball players. Two gyro sensors were attached to the sternum and sacrum, and three reflective plastic spheres were attached to the acromion and elbow. Four digital cameras were used to monitor pitching motion for analysis of rotation angle of the pelvic and trunk and abduction of the shoulder. Shoulder abduction angle was measured at Maximum External Rotation (MER) phase to evaluate pitching form, i.e. proper pitching or improper pitching from the point of view of elbow injury. The Mann-Whitney U test was used for statistical analysis.

### **RESULTS:**

Shoulder abduction angle varied  $-26^{\circ} \sim 14^{\circ}$  in the phase of MER. Negative correlation among the shoulder abduction angle and pelvic rotation was revealed statistically ( $r = -0.62$ ,  $P < 0.001$ ). According to the average value of pelvic rotation by Oi et al, we classified two groups, close group (pelvic rotation  $48.0^{\circ}$  or less at Stride Foot Contact (SFC),  $n = 11$ ) and open group (pelvic rotation  $49.0^{\circ}$  or more at SFC,  $n = 12$ ). Shoulder abduction angles in close group were significantly higher than those in open group ( $p < 0.02$ ). The angles of sternum tilt and rotation were significantly smaller in close group than in open group. There was positive correlation among pelvic rotation and sternum tilt and rotation at SFC.

### **CONCLUSION:**

The shoulder abduction angle at MER, which is key point of form in pitching associated with shoulder and elbow injury of growing baseball players, strongly related with pelvic and trunk rotation. Since it is difficult to modify the pitching form after acceleration phase, we recommend to instruct players to control pelvic and trunk motion before SFC phase in order to prevent shoulder and elbow injury in growing baseball pitchers.

## **CHANGES IN UPPER EXTREMITY MUSCLE STRENGTH AND ELBOW JOINT INSTABILITY AND THROWING MOTION AFTER REPETITIVE THROWING**

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### **INTRODUCTION:**

Recent studies have reported that repetitive overhead throwing could result in elbow injury. However, few studies have investigated the effects of repetitive overhead throwing on upper extremity muscle strength, elbow joint instability, and throwing motion. The present study aimed to determine changes in upper extremity muscle strength, elbow joint instability, and throwing motion associated with repetitive overhead throwing.

### **METHODS:**

Fifteen healthy baseball players participated in this study (mean age,  $22.3 \pm 1.9$  years; mean height,  $171.1 \pm 3.0$  cm; mean weight,  $67.3 \pm 8.0$  kg). We assessed the isometric strength of the serratus anterior (SA), upper trapezius (UT), middle trapezius (MT), lower trapezius (LT), and shoulder external rotation in the zero position (ZE) using a handheld dynamometer. Elbow joint instability was measured as the distance between the trochlea of the humerus and the coronoid process of the ulna under gravity stress applied using an ultrasonographic machine. Throwing motions were analyzed using a three-dimensional motion analysis system, and elbow varus moment at maximum external rotation (MER) of the shoulder was calculated during the late cocking phase. Data for each variable were obtained before and after the participants pitched 60 balls. Variables were compared between before and after the pitches using paired t tests. The significance level was set at  $p < 0.05$ .

### **RESULTS:**

Elbow varus moment and UT strength did not significantly differ between before and after the throwing session. The strength of the SA, MT, LT, and ZE significantly decreased after, the throwing session compared with before the throwing session ( $p = 0.030$ ,  $p = 0.005$ ,  $p < 0.001$  and  $p = 0.045$ , respectively). In addition, elbow joint instability significantly increased after the throwing session compared with before throwing session ( $p = 0.005$ ).

### **CONCLUSION:**

Elbow joint instability has been found to be associated with elbow pain. Increased elbow joint instability after repetitive overhead throwing of 60 pitches is important result in consideration of established pitch count restrictions.

ZE strength, which contributes to reducing elbow valgus stress, is affected by scapular muscle strength. Repetitive overhead throwing affected the scapular muscles, especially the SA, MT, and LT, which are implicated in scapular stability. Thus, scapular instability might lead to a decrease in ZE strength. This study found no change in the elbow varus moment at the MER between before and after the throwing session. Therefore, decreased strength of the upper extremity muscles after 60 overhead pitches minimally influenced throwing motion. However, continual pitching with decreased upper extremity muscle strength might increase the load on the elbow joint. The relationship between repetitive overhead throwing and elbow joint load requires further study.

## **IMPACT OF THE PREVIOUS SPORTS EXPERIENCE ON THE CURRENT STRENGTH OF TOE PLANTAR FLEXION OF YOUNG FEMALES**

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### **INTRODUCTION:**

The ambulatory ability would be essential for the quality of life in aged people. The contraction of toe plantar flexion muscles provides the stabilized walking [1], and strength of toe plantar flexion (STPF) has negative correlations with the risk of falls [2], however, reduces by

aging [3]. According to the reversibility in the principles of training, the acquired effects by training will start to diminish gradually if it stops. On the other hand, STPF is demonstrated while walking and even standing in daily life. Therefore, we hypothesized that STPF gained by sports would be maintained to some extent. The purpose of this study was to investigate the impact of the previous sports experience on the current STPF of young females.

**METHODS:**

42 young healthy female participants (mean age:  $24 \pm 4$  years) answered a questionnaire about the current and previous sports engagements lasting more than a year. According to the answers, they were divided into 2 groups: a current-sports group (CS:11) and a non-current-sports group (non-CS:31). The non-CS was divided into a previous-sports group (PS:21) and a non-previous-sports group (non-PS:10). The F-scan II system was used to measure STPF in standing. A sensor sheet was fixed on the plantar of right foot with the custom-made YK sensor stabilizer. The collected STPF value was divided by weight. The Shapiro-Wilk test was performed to assess data normality, and STPF values were compared between groups using independent t-test or one-way analysis of variance. All statistical analyses were performed using IBM SPSS version 25 for windows. Values of  $P < 0.05$  were considered significant.

**RESULTS:**

Average of STPF value for each group was as follows: CS ( $1.44 \pm 0.98$  N / kg), non-CS ( $1.26 \pm 0.73$  N / kg), PS ( $1.44 \pm 0.75$  N / kg), non-PS ( $0.88 \pm 0.52$  N / kg). There was no statistical difference between CS and non-CS ( $P = 0.539$ ), PS and non-PS ( $P = 0.196$ ), and PS and CS ( $P = 1.00$ ). The STPF value of PS was much larger than non-PS (170%) and almost the same with that of CS.

**CONCLUSION:**

Sports would strengthen STPF, and their strength could be maintained even after they stop playing. We found the sports experience would affect the current STPF. The experience of sports in early life would be recommended for a stabilized walking with the stronger STPF in later life.

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**DIFFERENCE OF LOWER EXTREMITY MUSCLE ACTIVITY AND KINEMATICS DURING SIT-TO-STAND AND STAND-TO-SIT MOVEMENT IN HEALTHY AND FALLER ELDERLY**

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**INTRODUCTION:**

Sit-to-stand (SitTS) and stand-to-sit (StandTS) movements are common and necessary in daily life. They require sufficient lower extremity muscle strength and the ability to control body stability. Failure to perform these represents some degree of disability and increases the risk of falling. Most studies focus on only healthy elderly or compare them to those with disease and surgery, observing SitTS duration, trunk movement, and lower extremity joint angle. These studies mainly focus on the analysis of kinematics, but very few combine this with EMG analysis or compare the characteristics of elderly who have fall history. In addition, there is less literature that discusses StandTS movements. Therefore, the purpose of this study was to compare the differences between lower extremity kinematics and EMG signals in healthy and faller elderly performing SitTS and StandTS movements.

**METHODS:**

There were four male elderly recruited in the current study ( $74.8 \pm 4.6$ ). Two were healthy and two had fall history at least once in the past year. All elderly were free of any neurological or musculoskeletal problem. Kinematics data were collected synchronously by 8 VICON cameras (200 Hz) and 2 Kistler force plates (1000 Hz). Delsys Wireless electrodes (2000Hz) were used for collecting muscular activation of gluteus maximus (Gmax), biceps femoris (BF), vastus lateralis (VL), vastus medialis (VM), rectus femoris (RF) and lateral gastrocnemius (GL) of the dominant leg. Participants were asked to perform sit-to-stand and stand-to-sit movements using a box with height equal to calf-length, and sitting at half the length of the thigh for 3 trials. Descriptive data were presented in this study.

**RESULTS:**

Compared to healthy elderly, faller elderly showed different muscle activation sequences, greater mean activation of muscles at each phase, greater trunk angle and faster trunk angle velocity.

**CONCLUSION:**

The activation sequence of healthy elderly is from distal to the proximal, and the sequence of elderly faller is from proximal to distal. The muscle activation in healthy elderly gradually increase when performing movements, but declines in the final phase (stabilization phase). However, the muscle activation in the elderly faller was gradually rising, and the activation during the stabilization phase is the highest. The previous study showed balance strategies of elderly fallers include more hip extensor muscles than distal muscles during standing. A similar strategy was also found from SitTS and StandTS. EMG data reflects the lack of lower extremity muscle strength in elderly fallers. Declining muscle strength might be the major factor in the elderly with falling experience. According to the results, one of the reasons that cause the elderly to fall was due to the weakness of the lower extremity muscles, which leads to insufficient movement control during SitTS and StandTS.

**RELATIONSHIP BETWEEN UPPER QUARTER Y BALANCE TEST PERFORMANCE AND THROWING PROFICIENCY IN ADOLESCENT HANDBALL PLAYERS**

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**INTRODUCTION:**

Handball is a sport mainly focused on executing throwing and passing techniques with the throwing arm. Functional specialization following the unilateral characteristic and dominance of the throwing arm may lead to adapted postural control (1, 2). Throwing is a key factor in handball with strength and mobility in combination with segmental stability as assessed through the Upper Quarter Y Balance Test (YBT-UQ) being of high importance (3). The present study tried to fill the gap of studies investigating adolescent handball players and their functional adaptation to a sport with a strong unilateral execution component in the upper extremities. We examined whether there are side differences between the throwing and the non-throwing arm. Additionally, correlations between the YBT-UQ and handball-specific performance measures were assessed.

**METHODS:**

All participants (13 females, age: 13 yrs, training experience [te]: 5.9±1.3 yrs; 24 males, age: 14 yrs, te: 6.5±2.5 yrs; 18 males, age: 15 yrs, te: 9.3±2.2yrs) were handball players of regional youth selection teams. The YBT-UQ was executed assessing medial, inferolateral and superolateral reach direction normalized to the upper limb length together with a composite score of the mean of all reach directions. A radar gun and a target net were used for the assessment of throwing velocity and throwing accuracy with three trials for each task, with the best one counted for velocity or points being awarded for accuracy. Pearson's correlation analysis was calculated for associations between YBT-UQ performance and throwing velocity/accuracy. The paired t-test was used to detect side differences in YBT-UQ performance.

**RESULTS:**

We detected small-sized correlations between YBT-UQ performance and throwing velocity/accuracy (13-year-old females:  $-0.01 \leq r \leq -0.37$  /  $0.01 \leq r \leq 0.31$ ; 14-year-old males:  $0.10 \leq r \leq .45$  /  $-0.01 \leq r \leq -.051$ ; 15-year-old males:  $0.06 \leq r \leq 0.34$  /  $0.01 \leq r \leq 0.45$ ), irrespective of age and sex category. Further, we only observed significant side differences between the throwing and non-throwing arm for the superolateral reach direction in the 14-year-old males.

**CONCLUSION:**

Based on the present results, there only seems to be a weak if any relationship between throwing performance and stability together with mobility of the upper extremities as assessed through the YBT-UQ. Future intervention studies should investigate whether the YBT-UQ is a useful tool to detect training-related improvements in measures of mobility, strength, and functional performance in adolescent handball players.

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**POSTURAL BALANCE IS GREATLY INFLUENCED BY NECK FUNCTION IN HEALTHY ICE HOCKEY PLAYERS**

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**INTRODUCTION:**

Cervical spine has not received much attention in relation to balance and sports performance. On the contrary, some attempts have been made to investigate balance in cervicogenic pathologies. Disturbances to the sensory input from the cervical region in those with neck pain may be a possible cause of unsteadiness and altered postural stability. As the upper cervical spine is neurophysiologically connected to the vestibular and visual system, it could importantly influence sensory-motor processes responsible for balance control. In hockey, specific head and neck posture during skating can alter cervical proprioceptive feedback. In aforementioned posture, some players can frequently place their lower cervical spine into flexion while keeping their upper cervical spine in extension. This can cause forward head posture, leading to altered kinaesthetic awareness of the head and neck. The goal of this study was to assess correlations between kinaesthetic awareness of the head and neck and postural balance in national level hockey players.

**METHODS:**

Twenty male ice hockey players participated in the study. Body sway was measured on a force plate (S2P, Ljubljana, Slovenia) while neck kinesthetic functions were assessed with the NeckCare gear and software (Reykjavik, Iceland). Parallel stance and single leg stances for both legs were measured under eyes opened and eyes closed conditions. Sway velocity in a-p and m-l directions were measured. Peak-to-peak frequency and median power spectrum frequency derived from a CoP movement in both directions were calculated. Neck kinesthetic function was assessed with the Butterfly test. Undershoot, time-on-target and overshoot of the head and neck movement relative to reference movement trajectory were calculated. Correlation analysis were done between all parameters.

**RESULTS:**

Dispersion of time-on-target had high, positive and statistically significant correlations with the velocity of CoP movement and amplitude in both a-p and m-l directions in eyes opened and eyes closed single leg stances. A trend of negative correlations between time-on-target dispersion and frequency of body sway was observed. On the contrary, median frequency of the power spectrum showed a positive correlation with the time-on-target dispersion in single leg stances. No significant correlations were observed for parallel stances, except for positive medium to high correlations between the overshoot, velocity and average amplitude of CoP movement.

**CONCLUSION:**

Time-on-target dispersion is a suggested indicator for robustness and efficiency of head and neck movement control. Its positive correlations to body sway in single leg stances indicates possible dependence of postural balance control on neck function in healthy athletes. This suggests balance in hockey players could benefit from training neck kinaesthetic function. The results of this study show promising results for better understanding the involvement of cervical function in sports specific tasks.

**A CONSTRAINTS-LED APPROACH FOR DETERMINING SPEED-ACCURACY TRADE-OFF IN INTERNATIONAL BADMINTON PLAYERS PERFORMING THE FOREHAND SMASH**

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**INTRODUCTION:**

The forehand smash in badminton is a skill which requires elite performers to gauge and determine the most appropriate speed-accuracy trade-off (SATO) given the task, environment and individual constraints (1, 2). Fitts' law (3) has often been characterised as an adept model for understanding SATO. Manipulation of constraints such as a target for accuracy has become a common coaching practise (4). The aim of this study is to determine and compare what SATO relationships international badminton players utilise when confronted with three constraint practises: maximal speed (MS) towards the direction of a target; maximal speed aiming to hit the centre of three shuttlecock tubes (TUBE); and maximal speed aiming to hit the centre of a circular target placed flat on the ground (TAR).

**METHODS:**

Fifty-two (males:29; females:23) international badminton players training/competing at the Glasgow BWF World Championships (2017) participated in the study. Racket-shuttlecock kinematics were collected using a Vicon 3D Motion Analysis System (400 Hz; OMG Plc, Oxford, UK). A  $\varnothing$  3m target (Podium 4 Sport) was placed flat on the centre line of the opposite side of the court to score accuracy (zero: centre circle=most accurate; five: out of bounds/net=least accurate) (5). Using percentage (TUBE;TAR) of MS shuttlecock speed and accuracy



score, a combination of two twostep cluster analyses (IBM SPSS V23) were used to identify clusters. A mixed ANOVA was used to analyse group\*constraint interaction.

**RESULTS:**

Three SATO relationships with different magnitudes (high (H): < 90%; moderate (M): 90-97%; low (L): > 97%) were identified in the cluster analyses: Inverse relationship (IR): decrease in shuttlecock speed, improvement in spatial accuracy; Alternative inverse relationship (AIR): shuttlecock speed increases, decline in spatial accuracy; Linear relationship (LR): Increase in shuttlecock speed, improvement in spatial accuracy. Clusters were combined (TUBE:TAR) to create 5 groupings: HIR:HIR; HIR:MIR; LLR:MIR; LLR:LLR; AIR:AIR. The mixed ANOVA revealed that group shuttlecock speed and accuracy score significantly differed across constraints ( $p < 0.001$ ). The LLR:MIR group increased shuttlecock speed and improved spatial accuracy the most from the MS to the TUBE condition.

**CONCLUSION:**

Elite badminton players adopt different SATO relationships when attempting to meet task constraint goals. A LLR can be used to produce fast and accurate smashes. Controlled constraint practises must be compared to those which incorporate more complex inter-personal dyadic interactions for both singles and doubles badminton.

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**A STUDY ON THREE-DIMENSIONAL MOTION ANALYSIS OF TURNS FOR DIFFERENT AMPLITUDES IN ALPINE SIT-SKI**

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**INTRODUCTION:**

When a turning manoeuvre is performed during skiing, external forces (gravity, snow resistance- and centrifugal force) act on the skier; at the same time, the skier exerts internal forces (load, edging, and rotation), in order to maintain his/her balance. In this scenario, both knee and hip movements are important to maintain balance (1). However, unlike a stand-ski, the sit-ski does not permit knee and hip movements. Therefore, upper body movements that supplement the balancing movements occur during a turn. The purpose of the present study was the three-dimensional motion analysis of the turning manoeuvre in a sit-ski and the clarification of its characteristics.

**METHODS:**

The study subjects included six skilled skiers (two sit-skiers and four stand-skiers), who were qualified instructors. All the study subjects performed the turning motion with narrow (1.5 m, N) and wide (3.0 m, W) amplitudes, on cones placed at 8-m intervals, at the maximum angle (FL), on a gentle slope (14 deg). On the third and fourth turns, the skier and ski movements were three-dimensionally analysed using the Direct Linear Transformation (DLT) method. The midpoints of the shoulders, hips, knees, and feet during the turns and the top of the head were digitized. Assuming that the FL direction was Y, the horizontal direction perpendicular to FL was X, and the vertical direction was Z, the displacement and velocity of each point and the centre of mass (COM) of the skier were calculated. In addition, the inclination angles of the head, COM, and knee, with respect to the slope, were calculated.

**RESULTS:**

The duration of one turn was observed to be longer in the N condition, compared to the W condition, while greater speed was observed in the N condition. In addition, the height of the COM (COMz) was observed to be low at the maximum amplitude and shifted higher when direction was changed, during the turn. The displacement was observed to be smaller and slower in sit-skiers, compared to stand-skiers. The inclination angle (IA) at the point of maximum amplitude (IAkn) in the stand-ski was in the order of the knee (IAkn) > COM (IAco) > head (IAhe); while IAco > IAhe leaned in the order. IAco in the sit-ski was greater than that of the stand-ski, and the maximum incline at the point of maximum amplitude was similar in both sit-ski (IAco) and stand-ski (IAkn).

**CONCLUSION:**

In the present study, the displacement of COMz, during a turn, was smaller in sit-skis, compared to stand-skis. Moreover, on analysis of the movement characteristics, the sit-ski was observed to permit only a limited range of upper body motion. In addition, since greater IAco was observed during sit-skiing, compared to stand-skiing, it was contemplated that the COM was significantly displaced and the inclining angle was adjusted during sit-skiing.

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**ASSESSMENT OF THE DYNAMIC RATE OF FORCE DEVELOPMENT SCALING FACTOR FOR THE ELBOW EXTENSORS: A PRE-LIMINARY STUDY**

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**INTRODUCTION:**

Recently, The Rate of Force Development Scaling Factor (RFD-SF) has been introduced as a measure of neuromuscular quickness capacity. RFD-SF represents the slope of the regression line derived from peak force (PF) and the corresponding RFD, obtained from ballistic contractions performed at different force levels (1). Although the RFD-SF has been evaluated for different muscle groups (2-3), it was mostly obtained under isometric conditions. Therefore, we designed a study aimed to test the feasibility of "dynamic" RFD-SF obtained from a series of ballistic movements against different external resistances.

**METHODS:**

Nine (five trained and four untrained) healthy subjects (age:  $34 \pm 10$  years) participated in the study. They were instructed to produce ballistic bilateral elbow extensions against five different constant forces (50 N, 100 N, 150 N, 250 N), controlled with the novel strength machine ("Vigour Xplosive", SE). Participants completed three trials against each resistance. Using RFD and PF from a set of recorded force-time signals, the slope (RFD-SF) and R2 obtained from linear regression were used as indicators of quickness and performance consistency,

respectively. Reliability of the PF and corresponding RFD were assessed through Typical Error of measurement (TEM) in terms of Coefficient of Variation (CV %) and intraclass correlation coefficient (ICC 3,1), while the sensitivity was assessed comparing RFD-SF and R2 between trained and untrained subjects using t-test for independent samples and Mann-Whitney U test respectively. Alfa level was set to 0.05.

**RESULTS:**

TEM was 3.5% for PE and 5.1% for RFD, while ICC (3,1) was 0.997 (0.994÷0.998) for PF and 0.980 (0.970÷0.990) for RFD. While the RFD-SF in trained group ( $10.72 \pm 0.36$ ) 1/s) was lower than in untrained group ( $12.06 \pm 0.40$ ) 1/s), no between group differences were recorded for R2 (median R2 = 0.974 for trained, and 0.970 for untrained).

**CONCLUSION:**

The main findings of this preliminary study are: 1) High reliability of the variables (PF and RFD) used to derive RFD-SF; 2) RFD-SF could identify differences in quickness between trained and untrained subject; 3) all subjects, regardless of their training history showed high-performance consistency. Although this was a preliminary study performed on a very small sample, the obtained findings suggest that quickness and movement consistency of elbow extensors could be adequately assessed from ballistic movements against different external resistance. ž

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### **BIOMECHANICAL ANALYSIS OF CONTINUOUS THRUST IN KARATE KATA**

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**INTRODUCTION:**

Karate is a martial art classified among those specialties requiring high technical skills such as a fine control of movement both in static and dynamic conditions, accompanied by a great ability to perform the main technical actions (strikes and kicks) as fast as possible ("ballistic actions"). Karate is classically divided into two different specialties: Kumite and Kata. Kata, (literally: "form") represents a real combat with imagery opponents. Karate is an Olympic event in Kumite and Kata. According to Valentina et al., Kinematics and neuromuscular activity can be assessed during the Kata Unsu jump performed by top level karateka. But the only significant improvement associated with the modified technique was evidenced at the beginning of the aerial phase, while there was no significant improvement of the referee score. But there are few biomechanical studies on Karate Kata, and the factors for victory are not clear. The purpose of this study was to investigate the effect of different proficiency levels in karate on biomechanics parameters.

**METHODS:**

The subjects were elite karate player (2012 World Karate Championship champion) and general karate player (5th National Sports Festival). Athletes volunteered to participate in the study after signing a written informed consent form. An eight camera Qualisys Track Manager (QTM) system ( $f_s = 500$  samples-s<sup>-1</sup>) was used to reconstruct the 3D position of 42 reflective spherical markers attached using adhesive tape to the participant skin and tights. Forces exchanged with the ground were measured using two six-components AMTI platforms. Participants were asked to assume the initial posture, Zenkutsu Dachi, with their anterior right foot on one force platform, while the rear left foot was another force platform. They were first instructed to perform a continuous thrust in the basic motion.

**RESULTS:**

As a result, the vertical amplitude of the ground reaction force was smaller in elite karate players than in general karate players. In addition, elite karate players also had a small area of the center of pressure of the ground reaction force. For elite karate players, the ground reaction of the front and rear feet exerted force in the opposite direction. It was considered that the continuous thrust movement of the elite karate player had little change in the load applied to either of the front and rear feet, and the movement of the center of gravity was small. This indicates that the body is rotating around the physical axis due to sharpness.

**CONCLUSION:**

It was considered that the continuous thrust movement of the elite karate player had little change in the load applied to either of the front and rear feet, and the movement of the center of gravity was small. This indicates that the body is rotating around the physical axis due to sharpness. It has been suggested that elite karate players perform better using physical axes than general karate players.

### **BIOMECHANICAL ANALYSIS OF THE MEN'S 400 M HURDLES AT THE IAAF WORLD ATHLETICS CHAMPIONSHIPS DOHA 2019: RHYTHMIC STRUCTURE AND EFFORT DISTRIBUTION.**

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**INTRODUCTION:**

The 400 m hurdles race is a rhythmic sprinting event. Speed and speed endurance are basic requirements, but the ability to express these in a rhythmic pattern is more important. Then, race distribution and rhythmic structure are very important for a successful in this event (1). There have been numerous studies of the 400 m hurdles over the last few years. However, the 400 m hurdles race is an athletic discipline rarely subjected to official individual biomechanical study at World Championships or Olympic Games (2).

**METHODS:**

The rhythmic structure and effort distribution of the nine men's 400m hurdles races of the IAAF World Athletics Championships Doha 2019 have been analysed: 5 heats (37 athletes), 3 semi-finals (24 athletes) and 1 final (8 athletes). Thus, 69 individual performances have been analysed. 87 variables of each athlete by race were analyzed, 19 qualitative and 68 quantitative (including spatial, temporal and spatio-temporal parameters), related to the

rhythmic structure and effort distribution. All races were recorded by 3 cameras (2 Casio Ex-F1 and 1 Sony A9) placed in different positions of the stand of the

Khalifa Stadium, permanently recording all the participants in each race and also recording the output trigger signal. The images were analysed using Kinovea (v.0.8.15) software.

**RESULTS:**

Related to the stride patterns or rhythmic structures, uniformity is non-existent and most patterns are individual (one-person). Most of the athletes do not repeat stride patterns from one round to the next. 22 different rhythmic structures have been found in heats, 13 in the semi-finals (including 5 new ones) and 6 in the final (including 1 new one). None of the finalists repeats rhythmic structure in the disputed races. Moreover, the athletes who ran the fewest steps in the total race achieved better results ( $R_{xy} .577, p<.001$ ).

Related to the distribution of the effort, the best athletes are the ones with the lowest speed losses after the fifth hurdle, have the smallest time difference

between fastest and slowest interval, and less time wasted before the change of rhythmic structure in each section. A correlation curve between the time between hurdles and the final time has been found in the total of the sample, being the highest in the fifth rhythmic unit, between hurdles 5 and 6 ( $R_{xy} .823, p<.001$ ).

**CONCLUSION:**

A correct distribution of effort and a more stable rhythmic structure are determining factors to obtain the best results in the men's 400m hurdles event.

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**HETEROGENEOUS BICEPS FEMORIS LONG HEAD STIFFNESS DURING KNEE FLEXION SUBMAXIMAL ISOMETRIC CONTRACTION**

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**INTRODUCTION:**

Recent studies have revealed that there are biomechanical and physiological differences between different muscle regions. In the biceps femoris long head, these differences may be due to the existence of more than one motor nerve branch in this muscle's innervation. However, it is unclear whether this also translates into regional mechanical properties, specifically in terms of muscle stiffness. This study sought to investigate whether the biceps femoris long head stiffness differs between the proximal and distal regions during isometric knee flexion at different contraction intensities and muscle lengths.

**METHODS:**

Ten healthy individuals performed knee flexion isometric contractions at 20% and 60% of maximum voluntary isometric contraction with the knee flexed at 15 and 45°. Muscle stiffness and activity were evaluated using ultrasound-based shear wave elastography surface electromyography, respectively. The proximal and distal regions of the biceps femoris long head were assessed.

**RESULTS:**

Greater stiffness was found in the distal region ( $p=0.023$ ), particularly at a lower contraction intensity (i.e. at 20% of maximum voluntary contraction). Conversely, no differences between regions were observed for muscle activity. Overall, the present findings indicate that the biceps femoris long head presents a heterogeneous stiffness pattern along its length during isometric knee flexion.

**CONCLUSION:**

This study provides useful insight on the pathophysiology of hamstring strain injuries since the proximal region of biceps femoris long head is most commonly injured. Additionally, the present findings indicate that studies which assess muscle stiffness at a single muscle site should be interpreted with caution. The investigation of in-vivo regional differences during active conditions should be extended to other muscles.

**THE INFLUENCE OF DIFFERENCES IN FRICTION OF HOSIERY ON LOWER LIMB KINETICS DURING CUTTING MOTION**

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**INTRODUCTION:**

Socks functional purpose in aggressive physical activity, such as leisure sports and elite sports, is to reduce slippage by increasing friction between the feet and the shoe (1). Recently, functional socks (In-out nonslip socks: IOS) have been developed to increase the efficiency of lower extremity muscles in strenuous sports movement by minimizing the slipping of the foot in shoes. However, changes in the motor performance induced by functional socks are unknown. Therefore, the purpose of this study was to investigate the effectiveness of functional socks on lower limb kinetics during cutting motion.

**METHODS:**

Fifteen healthy young adults who have right foot as dominant foot participated in this study (Age:  $23 \pm 2$  yrs, Height:  $174 \pm 2$  cm, Body mass:  $71 \pm 7$  kg). Two different types of socks (Normal socks: NS, IOS) were provided and after full warm-up, each participant was asked to perform cross cutting maneuver wore with NS and IOS at turning angles as 30° and 60° (2). A three-dimensional motion analysis included 8 infrared camera and 1 force plate with sampling rate as 100Hz and 1000 Hz, respectively, was performed in this study. Also visual analogue scale (VAS) was applied to check the wearing comfort of socks (3). Two-way RM ANOVAs was performed.

**RESULTS:**

IOS showed statistically significantly higher maximal inversion moment compared to NS at cross-cutting 30° (IOS:  $0.46 \pm 0.25$ , NS:  $0.38 \pm 0.22$  Nm/Bw;  $P=0.01$ ). Also maximal medial-lateral ground reaction forces (IOS:  $0.57 \pm 0.14$ , NS:  $0.52 \pm 0.12$  Bw;  $P=0.04$ ), maximal plantarflexion moment (IOS:  $2.42 \pm 0.27$ , NS:  $2.31 \pm 0.28$  Nm/Bw;  $P=0.02$ ), and maximal inversion moment (IOS:  $0.62 \pm 0.31$ , NS:  $0.52 \pm 0.27$  Nm/Bw;  $P=0.01$ ) revealed significant differences between IOS and NS at cross-cutting 60°. Finally IOS showed the higher wearing comfort than that of NS.

**CONCLUSION:**

In this study, we found that IOS was functional and comfortable compared to NS. Our results suggests that IOS can play a positive role in various sports activities that perform strenuous movements. In addition, further investigation of the muscle activations of the lower extremities may be needed to clarify these results.

### THE INFLUENCES OF ASYMMETRIC SHOULDER MOBILITY AND IMPACT PERFORMANCE CAPABILITY IN GOLF

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#### INTRODUCTION:

In order to achieve consistent movements and accurate impact performance in a complex asymmetrical swing, golfers have to perform swing movements repeatedly. Therefore, it is inevitable that skeletal muscles cause asymmetric mobility adaptation. Notably in the swing, the shoulder needs to perform composite movements with asymmetry and almost full range of motion. Although asymmetric mobility has been shown to increase the risk of injuries (1,2), research on the relationship between asymmetric mobility and performance is still lacking. Therefore, this research aims to explore whether the performance of golfers will be affected by the asymmetry of the shoulder mobility.

#### METHODS:

This research was conducted on 17 proficient golf players with under 10 handicaps from the Taiwan Sport University. Participants performed 10 repetitions using a driver to hit the ball, and a GolfAChiver software was used to measure their Swing Path, Clubface Angle, Ball Direction and Launch Angle. Shoulder Mobility Movement Pattern of FMS was used to evaluate the subjects' shoulder mobility (3), and were categorized into 2 groups: Shoulder Mobility Symmetry group (SMS) & Shoulder Mobility Asymmetry Group (SMA). Independent samples t-test on SPSS 2.0 was used to statistically analyze the results.

#### RESULTS:

Ball Direction data presented significant difference ( $p=0.034$ ); Clubface Angle data presented a slight significant difference ( $p=0.066$ ); Swing Path and Launch Angle data presented no significant difference. The mean values of Clubface Angle ( $0.87 \pm 2.23$ ) and Ball Direction ( $-0.33 \pm 2.23$ ) from SMA were closer to 0 than SMS ( $3.20 \pm 2.47$  and  $2.3 \pm 2.20$  respectively).

#### CONCLUSION:

The results indicate that the Clubface Angle from SMA is adjacent to a straight ball direction. Although some studies have confirmed asymmetric mobility increases the risk of injury (1,2), the results of Ball Direction data from SMA, an important element of golf performance, indicates a positive influence. These results do not suggest disregarding the asymmetry of mobility but rather proposes to golfers that asymmetric mobility adaptation of skeletal muscles is inevitable when aiming to improve performance. Nevertheless, excessive asymmetry of shoulder mobility should be monitored carefully to prevent unnecessary injuries.

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### ASSOCIATION OF THE ROMBERG TEST WITH AGE, ADJUSTED FOR THE LOCOMOTIVE SYNDROME, IN COMMUNITY-DWELLING OLDER ADULTS IN JAPAN

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#### INTRODUCTION:

The Romberg ratio and difference, which reflect changes in body sway due to eye closure, increase significantly with age (Okuzumi et al., 1999, Fujita, et al., 2005), but the age-related increase in Romberg parameters appears inconsistent. The locomotive syndrome (LS) is a major factor of body sway in older adults, and can distort the correlation of age and body-sway parameters, including the Romberg test; however, the LS has not been studied as a confounding factor in statistical models to assess the abovementioned association. We conducted this study to assess age-related changes in Romberg tests, while controlling for the LS, in community-dwelling older adults in Japan.

#### METHODS:

We enrolled 51 community-dwelling elderly individuals (21 men, 30 women; age, mean $\pm$ SD: 73.8 $\pm$ 6.8 years). We diagnosed the LS by positive findings on either or both of the following tests: (1) a two-step test score (the distance between two steps divided by the subject' height; LS+ if score <1.3) and (2) a stand-up test (LS+: if difficulty standing up on one leg when rising from a 40 cm-high seat). The Romberg test was carried out on a force plate (sampling rate 100 Hz; Technology service, Nagano, Japan). Subjects stood barefoot on the force plate for 1 minute with their eyes opened or closed. The Romberg ratio and difference were calculated by the total length of the center of pressure during the test. We used the analysis of covariance adjusted for sex, body mass index, and LS, followed by multivariate comparisons with Tukey test to assess changes in the Romberg ratio and differences.

#### RESULTS:

The Romberg ratio tended to increase with age (60-69 years: 1.10 $\pm$ 0.04; 70-79 years: 1.13 $\pm$ 0.03; and  $\geq$ 80 years: 1.23 $\pm$ 0.05), and significantly increased in subjects  $\geq$ 80 years versus subjects in the 60-69 age group ( $p<0.05$ ). The Romberg difference tended to increase with age (60-69 years: 0.13 $\pm$ 0.05; 70-79 years: 0.18 $\pm$ 0.04;  $\geq$ 80 years: 0.36 $\pm$ 0.07), and significantly increased in subjects  $\geq$ 80 years compared to subjects in the 60-69 and 70-79 age groups ( $p<0.05$ ).

#### CONCLUSION:

This is the first reported evaluation of age-related effects, adjusted for the LS, on Romberg tests in community-dwelling older adults. Both the ratio and difference of Romberg tests increased with age after adjusting for the LS; these increases were remarkably greater after age 80 than in the age groups of 60-69 and 70-79, and indicate greater impairment of vestibular and proprioceptive system after age 80.

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### APPLICATION OF ASSISTED SPRINT WITH AND WITHOUT ASSISTED LOADS

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#### INTRODUCTION:

Assisted sprint (e.g. towing sprinting) has been reported as an effective training tool to improve maximal running velocity. Mero & Komi (1986) reported improvements of the neuromuscular programming due to over-speed running. However, high-velocity running can experience only a few steps, and therefore the training volume and chance are scarce and valued highly. In addition, very few attempts have been made to clarify the mechanics of assisted sprinting to improve sprint techniques. Therefore, the purpose of the present study was to examine the differences in running characteristics between with and without isotonic assisted loads. We hypothesized that the maximal sprinting with assisted towing can gain the steps with maximal velocity and improve the stride frequency with decreasing the vertical force production.

#### METHODS:

Eight trained male sprinters (age: 21.5±1.5 yr, 100-m personal best times: 10.62±0.14 seconds) performed 60-m maximal sprint running both unassisted (NORMAL) and assisted (ASSISTED) with a motorized towing device (1080SPRINT, 1080 Motion, Lidingö, Sweden) using 6 (for 5 of 8 sprinters) or 9 (for 3 of 8 sprinters) kg. In assisted sprinting, sprinters were towed from 0 to 25 m after then, released from the towing cable, and they tried to sprint as fast as possible until 60 m (RELEASED). During sprinting, ground reaction forces were measured using 54-force plates system. Sprint velocity over time was measured by a laser system. Step length and frequency were calculated from ground reaction force data.

#### RESULTS:

Maximal sprint velocity was 10.26±0.11 m/s in NORMAL, 10.30±0.22 m/s in ASSISTED, and 10.45±0.2 m/s in RELEASED. The sustainable distances over 98% of the maximal velocity of NORMAL were 21.4±3.9 m, whereas it was significantly longer in assisted sprinting (34.5±6.8 m,  $p<0.01$ ) than in NORMAL. Even after released from the towing, sprinters sustain the maximal velocity at 28.8±4.7 m (vs Normal,  $p<0.01$ ). In step characteristics, step length was shorter in ASSISTED than in NORMAL ( $p<0.05$ ). On the other hand, step frequency was greater in ASSISTED than in NORMAL ( $p<0.001$ ) and RELEASED ( $p<0.05$ ). Regarding the ground reaction forces, significantly smaller vertical ground reaction force impulse in ASSISTED than in NORMAL ( $p<0.05$ ), although there were no differences in GRF between NORMAL and RELEASED.

#### CONCLUSION:

The present study clearly showed that assisted sprinting can experience high-velocity of sprinting with longer distance than in unassisted sprinting. Even if maximal sprint velocity was almost similar among conditions, ASSISTED could increase step frequency and decrease step length with decreasing the vertical kicking force. It is suggested that maximal sprinting after released from assisted towing can be a more natural way to perform maximal sprinting compared to with towing assisted sprinting.

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### VALIDATION OF 2-D CAPTURE SYSTEM FOR BALL TRACKING IN FOOTBALL

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#### INTRODUCTION:

Tracking of the ball is of interest in football research, leading to the availability of commercial systems for line calls, goal line technology, tactical analysis, and play summaries. Optical electronic performance tracking systems (EPTS) have been used to track ball trajectories via single or multiple camera systems. Ball detection systems are already used in football; however, a 3-D capture system may be costly for sporting organisations. A 2-D single camera capture system may provide a cheaper alternative for ball tracking, with the aim of this study to validate this system against a VICON 3-D motion capture system in a controlled stadium environment.

#### METHODS:

A 36 camera 3-D motion capture system (VICON V16 Cameras, 100 Hz down-sampled to 25Hz, 30 x 30 m) was positioned in the centre of the football pitch within a stadium. Seven circular markers (6 cm diameter) were cut from reflective tape and placed on the ball at different locations for VICON, with data analysed using VICON Tracker. Video footage was collected via a Panasonic 4K camera (PTZ AW-UE70KE, 25 Hz) mounted perpendicular to the test area. ProAnalyst (Xcitex Inc.) manually tracked the ball on the ground only, with the out-of-plane motion accounted for (1). Players performed four slow kicks, three fast kicks, and a dribble around the VICON capture area perimeter. Systems were compared for kicks (ball velocity and distance), and dribbling (XY position). Root mean squared difference (RMSD) was used to determine the error between systems.

#### RESULTS:

The RMSD between ProAnalyst and VICON for slow kicks was; distance: 0.02 m, and velocity: 0.60 m.sec<sup>-1</sup>, and for fast kicks; distance: 0.08 m, and velocity: 2.07 m.sec<sup>-1</sup>. Position differences during the perimeter dribble were 0.07 m for X-axes and 0.21 m for Y-axes.

#### CONCLUSION:

The two systems had good agreement, with differences unlikely to affect tactical or ball movement variables that might be of interest to a coach and scientist, for example relative distance of the ball from players. Although, this error needs to be considered if the context of the data's usage concerns ball speed, such as the velocity of ball movement across the pitch during a game. Differences in ball position and distance are likely due to ProAnalyst tracking the entire ball (effectively a 22cm diameter marker) compared to VICON tracking seven 6 cm markers, or the cameras ability to differentiate the ball from the scene at speed (2). A simple 2-D single camera ball tracking system can be used to track ball position and evaluating lower ball speeds, however higher ball speeds should be viewed with caution.

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**KINEMATIC CHARACTERISTICS OF TAKE-OFF AND HURDLE CLEARANCE PHASES IN MALE AND FEMALE ELITE HURDLERS**

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**INTRODUCTION:**

Performance of male and female hurdlers strongly depends on their movement technique, which, therefore, attracts a lot of scientific interest. Nevertheless, technical preparation of male and female hurdlers requires a thorough understanding of possible biomechanical differences in performance of these groups of athletes. So, the purpose of this study was to compare kinematic characteristics of take-off and hurdle clearance phases of male and female elite hurdlers.

**METHODS:**

Data from 110 m Hurdles Men's (1) and 100 m Hurdles Women's (2) biomechanical reports for the London 2017 IAAF World Championships were used for the analysis. The take-off and clearance phases at the 6th hurdle for male and the 5th hurdle for female finalists were studied. The independent t-test was applied to determine the significance of mean differences between the variables in male and female athlete groups.

**RESULTS:**

The results have shown that the take-off distance was significantly greater in the male group ( $2.24 \pm 0.13$  and  $2.10 \pm 0.09$  m,  $p=0.032$ ), but there were no significant differences in the relative take-off distances between men and women ( $1.20 \pm 0.07$  and  $1.26 \pm 0.08$ ,  $p=0.140$ ). No significant difference was found in ground contact time at take-off before the hurdle ( $0.128 \pm 0.008$  and  $0.121 \pm 0.009$  s for men and women,  $p=0.150$ ). Men had a smaller trunk-thigh angle at take-off phase ( $68.1 \pm 10.1$  and  $78.4 \pm 6.5^\circ$ ,  $p=0.029$ ). The deviation angle did not differ between the groups ( $64.4 \pm 1.7^\circ$  for men and  $62.8 \pm 2.4^\circ$  for women,  $p=0.167$ ). Hurdle flight time, hurdle distance and landing distance, and also relative hurdle distance and relative landing distance were significantly higher in male group ( $p$  from 0.008 to 0.000).

**CONCLUSION:**

A greater absolute height of the hurdles for men resulted in taking-off farther away from the hurdle. This, however, did not influence the deviation angle; apparently, due to the greater height of the hurdle for men. At the same time, male and female hurdlers performed the take-off from the same relative distance. Probably, men hurdlers cannot increase the relative distance to the hurdle because of a smaller relative distance between the hurdles ( $4.89 \pm 0.14$  for men and  $5.07 \pm 0.13$  for women,  $p=0.017$ ). The attack of the relatively higher hurdle from the same relative distance created less comfortable conditions for male athletes comparing to female athletes. In such situation male athletes had to lift a thigh of the lead leg higher for successful attack of the hurdle; it can be seen that trunk-thigh angle at take-off was significantly larger for women, while differences in trunk angle were not significant. Thus, there are significant differences of take-off and hurdle clearance phases kinematics in male and female elite hurdlers, which should be considered in training.

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**FOREARM MUSCLES EMG ACTIVITY DURING MAXIMAL ISOMETRIC FINGER-HANGS IN ROCK CLIMBERS: A COMPARISON OF THREE GRIP POSITIONS.**

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**INTRODUCTION:**

Finger-strength training is of high importance to optimize climbing performance [1]. During climbing, different grip positions can be used depending on the hold or surface characteristics (size, depth, shape). Grip positions commonly used in training and climbing scenarios are: (a) the crimp grip (CRIMP) with the proximal interphalangeal joints at  $90^\circ$  and distal interphalangeal joints hyperextended [2,3]; (b) the slope grip (SLOPE) with both interphalangeal joints in flexed position [2,3]; and (c) the sloper grip (SLOPER), a variation of the SLOPE when grasping a curved and big hold. Little is known regarding differences in muscular activity among them. This information could help optimize finger-strength training procedures. Thus, our aim was to assess differences in EMG activity of the forearm muscles in adults when using CRIMP, SLOPE and SLOPER during maximal isometric finger-hangs.

**METHODS:**

Twenty-five climbers (sex=22m/3f, age= $28.7 \pm 7.3$  years, height= $170.7 \pm 22.2$  cm, mass= $75.1 \pm 23.2$  kg, Watts climbing grade[4] =  $2.55 \pm 0.75$ ) performed an incremental tests to reach the maximum load that they could hold for 5 s while they were hanging from a climbing hold using CRIMP, SLOPE and SLOPER. Grip positions were presented in random order. Holds of 21 mm deep flat edge for CRIMP and SLOPE and 60 mm radius half-cylinder for SLOPER were used. Two maximum load trials per grip position were performed and EMG activity of four forearm muscles was registered: flexor digitorum superficialis (FDS), flexor digitorum profundus (FDP), flexor carpi radialis (FCR), and extensor digitorum communis (EDC). The root mean square (RMS) of each trial was computed for a 2-s window beginning 1 s after the trial started. Differences among grip positions for the two-trial averaged RMS values for each muscle were evaluated through RM-ANOVAs.

**RESULTS:**

RMS comparison revealed greater FCR and FDS activity when using SLOPER compared to CRIMP ( $p < 0.002$  and  $p < 0.006$ ) or SLOPE ( $p < 0.001$  and  $p < 0.001$ ). In addition, CRIMP also showed greater FDS activity compared to SLOPE ( $p = 0.001$ ).

**CONCLUSION:**

These results revealed that, under maximum load conditions, SLOPER could greatly stimulate FCR and FDS compared to the other two grip positions. Our results also indicated that the use of CRIMP resulted in a greater stimulus for FDS compared to SLOPE. When seeking maximum activation of digit flexor muscles, SLOPER grip positions should be included in training protocols.

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## CP-BM02 Walking, Running, Jumping

### SEX INFLUENCE ON THE FUNCTIONAL RECOVERY PATTERN AFTER A 20 KM GRADED RUNNING RACE

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#### INTRODUCTION:

Women are reported as usually less fatigable than men for similar intensity of fatiguing isometric contractions, but sex difference in fatigability is also known as task specific (1). Over the last 25 years, participation and performances of women have risen in endurance running races (2). However, information is lacking about the women functional recovery pattern as compared to the classical biphasic pattern reported for the men (3). This study investigated the sex influence on the acute and prolonged fatigue effects of a 20 km graded running race (~ 400 m) on the neuromuscular function of recreational runners.

#### METHODS:

Nineteen healthy runners (32±7 yrs), 10 women (W) and 9 men (M), completed the race. The testing protocol included 5 sessions: a week before (PRE), 35±15 min after (POST) as well as 2h, 2 and 4 days later (2h, 2D & 4D). Each session included 3 maximal tests: a bilateral isometric maximal voluntary contraction of the knee extensors (KE MVC), a squat jump (SJ) and a drop jump (DJ). Muscle soreness was quantified using visual analogic scale (0-10). The KE MVC analyses focused on the bilateral peak force. Vertical ground reaction force (1500 Hz) was used to calculate jumping height, relative maximal power output, as well as mean force and speed values. Men and women racing times were compared using independent t-test. One-way repeated ANOVAs were used to test the functional recovery along time of each sex group separately ( $\alpha = 0.05$ ).

#### RESULTS:

Racing time did not differ between men and women (M: 125±15, W: 128±23 min; NS). Muscle soreness was slightly increased at POST, 2h and 2D ( $p < 0.001$ ) for each group. The SJ test did not reveal any significant change. The KE MVC test revealed significant decreases in peak force for both men and women, but only at POST and 2h (M: -46±9 and -35±18%,  $p < 0.001$ ; W: -27±18 and -28±9%,  $p < 0.01$ ). In women, the DJ test revealed acute reductions in mean force (-13±8% at POST,  $p < 0.01$ ) and mean speed (-11±7 at POST and -10±14% at 2h,  $p < 0.05$ ). Men presented both acute and delayed decrements in DJ height (from POST: -21±15 to 2D: -14±8%,  $p < 0.05$ ), relative maximal power output (from POST: -25±12 to 4D: -15±15%,  $p < 0.01$ ), mean force (from POST: -11±8 to 4D: -8±11%,  $p < 0.05$ ) and mean speed (from POST: -14±7 to 4D: -7±6,  $p < 0.05$ ).

#### CONCLUSION:

According to our knowledge, this is the first 20 km running study describing up to 4 days the functional recovery pattern of women versus men. In line with earlier studies (3) on men, women presented larger acute decreases in KE MVC than in jumping type performances that are closer to the running ones. Comforting the less fatigable women hypothesis (1), our results emphasize the absence of delayed functional decreases for the sole women.

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### JUMP PERFORMANCE INCREASES AFTER A CONDITIONING SQUAT EXERCISE

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#### INTRODUCTION:

A brief maximal isometric voluntary contraction (MVC), used as a conditioning contraction (CA), enhances muscle contractile properties, a phenomenon known as post-activation potentiation (PAP) (1). PAP has been suggested to increase the rate of force development of single joint voluntary contractions (2). However, the influence of PAP on multi-segmental movements, such as jumps, is still a matter of debate, especially during the first 5 min following the CA during which PAP is observed (2,3). These contrasting results likely reflect, in part, the diversity of the CA characteristics. In the present study, we examined the influence of a well-documented CA (6-s MVC; (2)) on counter-movement jump (CMJ).

#### METHODS:

Fifteen physically trained young (23.7 ± 3.8 yr) adults completed one familiarisation session and one experimental session, which consisted of 10 recording sequences. Five sequences assessed the effect of CA [6-s MVC in back squat position (knee angle: 90°) on a Smith machine] on CMJs, and five sequences with similar timing that CA sequences, but without CA, were used as control (CON). In each sequence, three CMJs were performed 1 min before CA or rest (CON), and at either 1, 2, 3, 4 or 5 min after CA or rest (CON). A 10-min rest period separated two successive sequences. The CMJs were performed on a force platform to calculate the jump height, the net impulse – and its duration – of the unweighting, braking, propulsion phases of the CMJ.

#### RESULTS:

Averaged across sequences, the baseline CMJs height was 35.3 ± 5.9 cm. None of the variables changed during the control sequences. In comparison with baseline CMJs, jump height (+5.5%) and the impulse of the propulsion phase (+2.6%) increased ( $p < 0.05$ ) when CMJs were performed 2 min after the CA, without change in the duration of the propulsive phase. These changes were statistically greater than those observed during the 2-min control sequence ( $p < 0.05$ ). No other variables changed in the CA sequences, regardless of the delay between the CA and the CMJs.

#### CONCLUSION:

Our results show that a 6-s MVC in back squat position increased CMJ height by increasing the net impulse of the propulsive action when the CA preceded the CMJs by 2 min. This 2-min delay indicates that CMJ enhancement might be due, at least in part, to PAP. Overall, this study suggests that brief maximal isometric squat exercise can be used in training routines to improve jump performance.

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**CADENCE MODULATION IN GAIT: PACING STEPS OR STRIDES?**

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**INTRODUCTION:**

A change in cadence during walking or running might be indicated for a variety of reasons, among which mobility improvement and injury prevention [1,2]. Auditory pacing may be used to modulate cadence through auditory motor coordination, with a more stable coordination indicating stronger modulation [1]. Auditory-motor coordination is influenced by coupling strength (i.e. the strength of the interaction [1,3]) and detuning (i.e. the frequency mismatch [4]) between the movement and the pacing cues, a phenomenon inherent to cadence modulation. In this study, we compared the effectiveness of step-based (one cue per step) and stride-based (one cue every other step) auditory pacing for cadence modulation in both walking and running at three pacing frequencies.

**METHODS:**

Sixteen experienced runners walked and ran on a treadmill while synchronizing their footfalls with step-based and stride-based pacing at slow, preferred and fast pacing frequencies in synchronization-perturbation and synchronization-continuation trials. We quantified the variability of the relative phase between pacing cues and footfalls and the responses to perturbations in the pacing signal as measures of coordinative stability [5]. Furthermore, we quantified the deviation from the prescribed cadence after removal of the pacing signal as a measure of internalization of the prescribed cadence [6].

**RESULTS:**

The synchronization needed for modulation was not reached in all trials. Synchronization was reached less often in running, especially in the conditions with a slow pacing frequency. If synchronization was reached, coordinative stability was similar for preferred and fast pacing frequencies. Step-based auditory pacing led to more stable auditory-motor coordination in both walking and running. Participants showing synchronization showed good internalization of the paced cadence in all conditions.

**CONCLUSION:**

The similar coordinative stability for preferred and fast pacing frequencies suggests that auditory pacing can be an effective method to increase cadence. The more stable coordination with step-based pacing indicates stronger modulation with this type of pacing. In conclusion, step-based auditory pacing can be used to increase cadence in walking and running, provided that the user is able to synchronize to the pacing signal.

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**COMPARISON OF SPATIOTEMPORAL AND KINEMATIC VARIABLES DURING SPRINTING BETWEEN KENYAN AND JAPANESE CHILDREN**

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**INTRODUCTION:**

Running ability such as speed and stride patterns is improved during growth and development. However, it is unclear whether the level of improvement is different between ethnicities. In the present study, we aimed to clarify the differences in spatiotemporal and kinematic variables during 50-m sprinting between Kenyan and Japanese pre-puberty children.

**METHODS:**

Twenty Kenyan urban children (12 boys and 8 girls) and 25 Japanese urban children (14 boys and 11 girls), who were 10-11 years old, participated in this study. The measurement of 50-m sprinting was carried out on a straight runway in gravel track. Running motion in the sagittal plane was captured around the 35-m point from the starting line using a high-speed video camera (240fps). Spatiotemporal variables such as speed, step frequency, step length, contact time, and aerial time were calculated from the obtained movie. Simultaneously, the positions of five body landmarks (great trochanter, the center of knee joint, lateral malleolus, heel, and fifth metatarsal phalangeal joint) were digitized, and kinematics of lower limb joint (hip, knee, and ankle joint) was determined.

**RESULTS:**

Both in boys and girls, there was no significant difference in sprinting speed between Kenyan urban children and Japanese urban children ( $p = 0.40$  in boys and  $p = 0.77$  in girls, respectively). However, Kenyan urban boys showed significantly lower step frequency ( $p < 0.05$ ) and longer aerial time ( $p = 0.03$ ) compared with Japanese urban boys. Concerning kinematic variables, knee extension velocity was higher in Kenyan boys than Japanese boys ( $p = 0.02$ ) in the stance phase. On the other hand, knee flexion velocity in the swing phase tended to be lower in Kenyan children than Japanese children ( $p = 0.01$  in boys and  $p = 0.08$  in girls, respectively). Moreover, there was a significant difference in lower limb length between Kenyan urban children and Japanese urban children ( $p < 0.05$  in boys and  $p = 0.01$  in girls, respectively), with Kenyan urban children's for approximately 2 to 5 cm longer than that of Japanese urban children.

**CONCLUSION:**

Although there was no significant difference in sprinting speed, Kenyan urban children ran with longer step length, and Japanese urban children ran with higher step frequency compared with each other. Shorter limb length in the lower limb in Japanese children may affect biomechanical variables during running. On the other hand, in Kenyans, it is also possible that longer step length than optimum can cause braking effects and thus slow speed and or using more energy. Future studies will need to combine biomechanics and energy expenditure or efficiency.

**DOES SURFACE TYPE AFFECT JUMP KINEMATICS OF RACEHORSES OVER HURDLES?**

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**INTRODUCTION:**



National Hunt (NH) racing comprises hurdle and steeplechase races. Hurdle races include >8 fences ~106.68cm high, angled at 28° for a minimum of two miles (3281.7m), run at average speeds of ~14.3m/s, and represent a higher injury risk. Racehorses race on turf but often train on synthetic surfaces, which may influence injury risk. This study investigated if racehorse hurdle jumping biomechanics changed between turf and a synthetic surface (SS).

**METHODS:**

Six experienced NH racehorses (5.67±0.47 years; varying ability), trained by the same trainer and racing in hurdle races were recruited for the study. Spherical markers were painted onto key anatomical landmarks of racehorses' left forelimb (FL), hindlimb (HL) and withers. Horses undertook their normal jump schooling routine: warm up followed by 3 repeats of 4 hurdle fences, week 1: on turf (firm going; 2% incline) and week 2: SS (23.4cm deep, polytrack plus synthetic fibre mix; no incline). Jumps were recorded using high-speed videography (960 frames/second) and Kinovea motion analysis software analysed the angle of trajectory at take-off and FL/HL joint angles at take-off, suspension and landing on each surface. Horse speed, duration of the jump and jump distance were also recorded. A series of Spearman's correlations and Wilcoxon Signed Rank analyses identified if relationships or differences occurred for the variables recorded between the two surfaces.

**RESULTS:**

Individual horses demonstrated consistency in their jumping biomechanics between jumps and surfaces. No significant differences occurred in FL or HL jumping biomechanics between the turf and SS across the cohort (P<0.05). However take-off angle was significantly increased on the turf surface (P=0.03). Moderate to good positive correlations (P<0.05; r>0.6) were found between horses' shoulder and knee angles on take-off, and the distances between the FL/HL fetlocks at take-off and landing. Fetlock angle on landing was decreased on turf (154.3±6.7°) compared to the SS (164.2±6.8°; P=0.05). Interestingly, approach speeds were faster for more successful horses (grouped by handicap) on both surfaces, but overall faster speeds were observed on turf. Significant negative correlations were found between approach speed and vertical velocity (P<0.05; r<-0.6) and horses' shoulder and hock angles. Whilst take-off angle was positively correlated to vertical velocity (p=0.01; r=0.81).

**CONCLUSION:**

The results suggest racehorses jump hurdles with a flatter, more acute trajectory on a SS compared to turf; this could be due to the softer and deeper surface of the latter which requires more propulsive force in the HL to clear the fence. Speed and vertical velocity were also associated with jumping biomechanics. Speeds here were slower than in racing, therefore the acute angles observed are likely to be increased, which could contribute to racehorse injury.

**A QUANTITATIVE COMPARISON OF SPINE EXTENSION RANGE-OF-MOTION DURING VERTICAL JUMPS WITH AND WITHOUT COUNTERMOVEMENT**

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**INTRODUCTION:**

The human spine, composed of 33 vertebral bones, has mobility, such as extension-flexion and rotation, similar to other joints. However, most biomechanical motion studies of vertical jumping simplify the human trunk to a single rigid-body segment, ignoring its range-of-motion (ROM). This study utilized a trunk model with six rigid-body segments and quantitatively compared spine extension movements during vertical jumps, with and without countermovements.

**METHODS:**

Ten healthy young males participated in this study. Each participant performed vertical jumps with maximal effort with and without countermovement without arm swing. A three-dimensional optical motion capture system (VICON MX) with 11 cameras was used for the experiment. Fourteen reflective markers were attached to landmarks on the participants' bodies; six markers were located on the tips of specific spinous processes, thus creating a two-dimensional trunk model with six rigid-body-segments in the sagittal plane. Accordingly, the total and local ROMs were evaluated using the angular displacement between each segment. A repeated measures t-test was performed to detect differences in the total ROM, with and without countermovement. A two-way repeated measure analysis of variance (ANOVA) was used to examine the effects of countermovement and the regional differences. Differences in the local ROM were measured with Holm's multiple comparison analyses.

**RESULTS:**

The total ROM during the propulsion phase was significantly greater with countermovement than without (92 ± 9° vs. 75 ± 8°, respectively; P <.05). The two-way ANOVA test revealed significant interaction between the effect of countermovement and the region of spine (P <.01). Regardless of countermovement, local ROM was greater at the upper and lower regions of the spine (around the upper thoracic spine and lumbar spine), and smaller at the centre of the spine (around the lower thoracic spine). The differences in local ROM, with and without countermovement, were also significant at the upper and lower regions of the spine.

**CONCLUSION:**

Concerning spine extension in vertical jumping, we concluded that (1) the local ROM was larger at the upper and lower regions of the spine, (2) the total ROM becomes larger with countermovement, and (3) differences in local ROM, with and without countermovement, were remarkable around the upper thoracic spine and lumbar spine.

**CP-BM03 Postural control****ASSOCIATIONS BETWEEN PERTURBATION-INDUCED LOCOMOTOR ERROR AND SUBSEQUENT ADAPTATION TO LARGE BALANCE PERTURBATIONS IN YOUNG AND OLDER ADULTS**

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**INTRODUCTION:**

Exposure to large balance disturbances in safe settings is a promising approach to exercise-based falls prevention. Perturbation magnitude, and thereby the motor error experienced (i.e. mismatch between intended and actual movement), may play a role in the generalisability of the adaptations (Yang et al. 2013) which is key for successful interventions in daily life. Here we investigated the association between initial locomotor error following an unexpected perturbation and subsequent gait adaptation.

**METHODS:**

30 young and 28 older adults (50% female; 24±2.5y and 71±4y) participated. For valid comparison and data pooling, inter-individual differences in gait stability were reduced using an individual, stability-normalised walking speed based on multiple gait trials (0.4m/s to 1.8m/s; McCrum et al. 2019). The speed that would result in margins of stability (MoS; Hof et al. 2005) of 0.05m was calculated. Participants then experienced 10 unannounced unilateral treadmill belt acceleration gait perturbations (every 30-90s): the first and tenth to the right leg (Pert1R and Pert10R); the second to ninth to the left leg (Pert2L-Pert9L). MoS was calculated for Pert1R, Pert2L, Pert9L and Pert10R at baseline (mean of 10 steps pre-perturbation) and the first eight recovery steps. The number of steps needed to return to baseline MoS (within 0.05m) was calculated for each perturbation and participant. To quantify improvement, the decreases in recovery steps from Pert2L to Pert9L (trained leg) and Pert1R to Pert10R (untrained) were calculated. As a proxy for initial locomotor error, the absolute differences in MoS for the first three recovery steps (where the most destabilising effects of such perturbations are experienced) following Pert1R and Pert2L compared to baseline were summed. Correlations were conducted between the change in steps for the trained or untrained legs and the initial locomotor error. Data are mean±SD.

**RESULTS:**

Numbers of recovery steps for Pert1R, Pert2L, Pert9L and Pert10R were 6.2±1.8, 5.9±1.6, 4.5±2 and 5.7±1.8, respectively. Improvements in number of recovery steps from Pert2L to Pert9L and Pert1R to Pert10R were not significantly correlated with locomotor error (Pert2L: 0.22±0.09m; Pert1R: 0.24±0.11m) at Pert2L (Spearman  $r=0.13$ ,  $p=0.35$ ) or at Pert1R (Pearson  $r=-0.26$ ,  $p=0.05$ ), though removal of one outlier in Pert1R altered the result (Pearson  $r=-0.35$ ,  $p=0.008$ ). No age-related subgroup differences were observed.

**CONCLUSION:**

These results do not suggest a strong relationship between initial locomotor error (quantified by acute change MoS) following a perturbation and subsequent adaptation. The neuromotor system likely quantifies error in a more complex manner that does not only depend on gait stability. However, for transfer of adaptations to untrained limbs, the results suggest that stability may indeed be one factor, albeit a minor one.

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## **POSTURAL MOVEMENT STRATEGIES AND CONTROL DURING SENSORY REWEIGHTING: EFFECT OF AGE AND GYMNASTIC EXPERIENCE**

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**INTRODUCTION:**

Postural control requires integration and adjustment of different sensory inputs' relative contributions when an individual faces a perturbation [1]. Evidence suggests gymnastic practice in children improves these reweighting processes during and after a proprioceptive alteration showing adult levels of COP displacements and velocities [2]. However, these COP characteristics could be achieved performing different motor strategies. Individual motor strategies can be defined by principal postural movement components (PP) of a principal component analysis (PCA). Sensorimotor control of postural movements can be characterized by the PP's first and second time-derivatives (principal velocity, PV, and principal acceleration, PA) [3]. Our aim was to assess motor strategies and sensorimotor control of children and adults with different gymnastic expertise (gymnasts, G, and non-gymnasts, NG) adjusting standing posture during and after bilateral tendon vibration.

**METHODS:**

Forty-two children (NG= 11 and G=31) and 35 adults (NG= 13 and G=22) equipped with body landmark markers and two vibrators strapped over the Achilles tendons were asked to stand quietly three 45-s trials in two visual conditions (eyes open, EO, and eyes closed, EC). Trial order was randomized and vibration lasted 10 s within each trial. PCA was calculated on normalized and weighted markers coordinates and yielded the PPs PVs & PAs. We quantified the contribution of each PP to the overall postural movements (PP relative standard deviations, PP-rSTD). Rate-dependent sensory information to each postural movement was characterized by PV-rSTD, and neuromuscular control of the postural movements was assessed via PA-rSTD. All variables were calculated for four 10-s phases within a trial: before vibration (BV), during vibration (DV), after vibration early phase (AV1), and after vibration late phase (AV2). 4 (Group) x 4 (Phase) x 2 (Visual condition) RM ANOVAs were conducted.

**RESULTS:**

Only NG children showed different motor strategies using less ankle movements in the anterior-posterior direction (PP1-rSTD) but increased the trunk rotations (PP4-rSTD) in DV and AV2. During and after vibration, they exhibited higher values of PA3-rSTD suggesting more hip action than the other participants.

**CONCLUSION:**

These results suggest preference for a "stick-like" strategy that moves from trunk/hips in NG children. Gymnastic experience during childhood may benefit the development of proprioceptive reweighting processes in children leading earlier motor strategies and control similar to adults.

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## **THE EFFECT OF MOVING SOUND ON BODY SWAYING**

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**INTRODUCTION:**

Virtual reality (VR) has become so widespread that it is used for education, training, and entertainment. However, some people develop symptoms like motion sickness called VR sickness. It is said that the difference between visual information and internal sensation is one of the causes, but the effect of auditory information on VR sickness has not been clarified. It is also known that hearing a moving sound

causes illusions of self-motion (vection), which results in increased movement of the center of plantar pressure (COP). We examined the effect of the sound movement on VR sickness and body swaying.

**METHODS:**

15 male college students were participated in the experiment. We used a sine wave with a magnitude of 60dB, a frequency of 500Hz, and a period of 1 second as the auditory stimulus and moved the sound source in virtual space. The moving direction of the sound source was set to three conditions: left rotation, right rotation and vertical movement. The moving speed of the sound source was set to two conditions: 1 m / s and 0.5 m / s. The experimental conditions were a total of 7 conditions (3 directions x 2 speeds + no sound). Seven conditions were set as one set, and a total of four sets were performed. The participants were instructed to stand on the plantar pressure measurement plate (Footscan 2D, RS International) with their eyes closed. The 20-second sound was presented in one trial through 5.1ch virtual surround headphones.

**RESULTS:**

The total distance of the COP movement was not shown to be significantly different on any conditions. However, in each condition, the maximum width of COP swaying in the front-back direction (Y-axis) was larger than that in the left-right direction (X-axis) ( $P < 0.05$ ). In addition, there was a surprising tendency that the maximum width of COP swaying was smaller in the sound conditions than in the no sound condition. In terms of way the COP is swayed, there were two patterns: micromotion and horizontal sway. The micromotion tended to occur more often under the sound conditions than the no sound condition. VR sickness and ECG baseline fluctuations were not shown in any conditions.

**CONCLUSION:**

One of the reasons why the maximum width of the COP swaying was larger increased in the no sound condition is that the rotating sound can help keep the posture. From the micromotion of the COP in the sound conditions, the maximum width of the COP swaying became smaller than that in the no sound condition. This would result from fine-tuning the posture by hearing the sound. In this paper, the effect of the sound movement on VR sickness is not so clear. More detailed researches are needed in the future.

**LOWER EXTREMITY KINEMATICS OF PERTURBED RUNNING USING A SPLIT-BELT INSTRUMENTED TREADMILL**

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**INTRODUCTION:**

Applying perturbation to the lower extremity during running provides an understanding of balance recovery, which might help to prevent falling or injuries. However, studies considering slip-like perturbations during running are rare. Therefore, the purpose of this study was to analyse kinematics of running on a treadmill while some perturbations were applied to the movement.

**METHODS:**

13 asymptomatic individuals (8 females/5 males,  $28 \pm 3$  yrs,  $171 \pm 9$  cm,  $68 \pm 10$  kg) completed an 8-minute running protocol at baseline velocity of 2.5 m/s. During running on a split-belt instrumented treadmill, 30 one-sided (15 each side) perturbations were superimposed to stimulate slip-like disturbances (in anterior-posterior direction). Perturbations were initiated 150 ms after heel contact (stance phase) by rapid deceleration/acceleration of the belt velocity (baseline to 0.5 m/s and return to baseline) within 100 ms. Running pattern was recorded using a 3D-motion capture system (13 cameras, 500 Hz). Joint angle of the ankle (plantarflexion/dorsiflexion, inversion/eversion and rotation planes), knee and hip (flexion/extension, abduction/adduction and rotation planes) were calculated for the perturbed side. Range of motion (ROM, [°]) and maximum angle (MAX, [°]) of all three segments were assessed for normal (NR) and perturbed running (PR) (whole stride). Data were analysed descriptively, followed by a Paired T-test to compare between unperturbed and perturbed strides ( $P < 0.025$ ).

**RESULTS:**

Statistical significant differences were observed between NR and PR in ROM of the ankle plantarflexion/dorsiflexion (NR= $48.0 \pm 8.8^\circ$ , PR= $34.5 \pm 7.8^\circ$ ) and knee flexion/extension angle (NR= $73.0 \pm 10.7^\circ$ , PR= $81.4 \pm 11.5^\circ$ ) and also hip abduction/adduction angle (NR= $17.0 \pm 4.4^\circ$ , PR= $14.6 \pm 3.1^\circ$ ) ( $P < 0.001$ ). MAX angle of the ankle in plantarflexion/dorsiflexion plane of NR ( $24.5 \pm 7.9^\circ$ ) was significantly higher than PR ( $22.9 \pm 8.0^\circ$ ) ( $P < 0.001$ ). Greater MAX knee flexion and external rotation in PR ( $91.3 \pm 12.0^\circ$ ,  $10.8 \pm 12.8^\circ$ ) than in NR ( $79.8 \pm 11.7^\circ$ ,  $6.1 \pm 11.8^\circ$ ) was observed. MAX hip flexion/extension in NR ( $40.2 \pm 9.1^\circ$ ) was significantly different from PR ( $46.4 \pm 8.1^\circ$ ) ( $P < 0.001$ ).

**CONCLUSION:**

Perturbations used in the current study required considerable compensation changes in movement pattern to control balance. As the present protocol has evoked stumbling in the anterior-posterior direction, accordingly, joint angles were influenced more in the sagittal (flexion/extension) plane. Greater maximum flexion of hip and knee joints in addition to increased plantarflexion of the ankle joint observed in the perturbed leg, suggest an attempt of the body to lower its mass for stabilisation and thereby preventing falling. Analysis of the unperturbed leg (swing leg) might further help to understand balance recovery strategies in response to running perturbations.

**DEVELOPMENT OF A PORTABLE DEVICE USING STOCHASTIC RESONANCE FOR STANDING BALANCE IMPROVEMENT**

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**INTRODUCTION:**

Standing feedback control is related to somatosensory information. Stochastic resonance is used to improve the function of standing balance by increasing the sensitivity of somatosensory information by noise stimulation. There are many sensory receptors in the fingertips and it has been studied that tactile sensation in the fingertips leads to a decrease in postural sway as a light touch effect. It suggested that noise stimulation on the fingers increases the sensitivity of the fingertip tactile sensation and consequently improves the standing balance function. The aim of this study was to development of a device that can improve sense of standing balance by electrical noise stimulation using stochastic resonance to the median nerve of the wrist.

**METHODS:**

Ten healthy subjects participated in the experiment. The developed portable device for balance improvement satisfies the specifications that can generate a noise signal and set the stimulus current value freely. The electrical white noise stimulation was applied to the median nerve of the right wrist for 40s for subjects in a standing posture with eyes closed using our developed device. The postural sway was evaluated by the center of pressure (COP) measured by a force plat and body movement (head, left waist and right waist movement)

measured by motion capture. The characteristic parameters of the posture sway calculated antero-posterior (AP) standard deviation (SD), mean AP velocity, AP area of the frequency domain for high frequency.

RESULTS:

It could be confirmed that the electrical noise stimulation for the median nerve of the right wrist reduced all three parameters at optimal intensity compared to no stimulus in seven subjects. The average reduction rates of the optimal intensity that based on no stimulation for all subjects showed decreasing trend for all parameters both COP and body movement. In particular, the mean AP velocity of COP was decreased 22.9 % ( $p < 0.01$ ), the mean AP velocity of left waist movement was decreased 32.1 % ( $p < 0.01$ ), the AP SD of left waist movement was decreased 12.2 % ( $p < 0.05$ ) and the AP area of the frequency domain of the left waist was decreased 12.5 % ( $p < 0.05$ ).

CONCLUSION:

These results indicate that the postural sway was reduced when electrical noise stimulation was applied to the median nerve of the right wrist and we could confirm the effectiveness of our developed device. There was a difference in the decrease rate of the parameter between the left and right waist movement. It is considered the left waist, which is opposite side of the stimulation side (right wrist), was the result of compensating posture control. This suggests that the fingertip tactile sensation is enhanced by the noise stimulus and that posture control is changed strategically. In further study, we investigate the effects of changing the stimulus side and changing the noise signal like pink noise.

## OPTIMAL CONTROL BASED ANALYSIS OF CHALLENGING SLACKLINE JUMPING

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INTRODUCTION:

Balancing on a Slackline is a sport where the athlete tries to stand, walk or jump on a spring-like ribbon band that is mounted between two anchor points. Maintaining balance in this situation is a challenging task in itself, however, experts manage to walk several hundred meters, jump and perform twists or somersaults. Contact forces are essential to understand how humans maintain balance, but they cannot be measured directly on a slackline and are not included in a conventional biomechanical analysis. We therefore developed a contact model for slackline balancing and used it in the context of an optimization based motion analysis. We demonstrate the method by analyzing a challenging slackline trick (1).

METHODS:

We captured a jumping motion with a 180° rotation of an experienced slackline athlete using 8 Qualisys 5+ cameras and the Gait-IOR marker set (2). From a static trial we constructed a subject-specific rigid body model. We formulated and solved an optimal control problem (OCP) that minimizes the distance of the recorded marker motion capture data and the virtual markers in the model. In a pre-study we used pressure insoles to investigate the athlete-slackline contact while standing and proposed a contact model for slackline balancing that includes the interaction forces and torques as well as the position of the center of pressure. We formulated the rigid body dynamics with multibody dynamics and contact forces as constraints to the optimization, resulting in a physically feasible optimized motion. We reconstructed the example jump motion and analyzed different physical quantities related to center of mass (CoM) motion and angular momentum (AM), and compare the results to a conventional analysis.

RESULTS:

The average marker fitting error was in average 3 cm for both methods. We demonstrated that Newtons Equations of Motions and are satisfied with our approach, conserving AM and showing the precise expected accelerations during flight phase. This is not the case for a conventional analysis in AM as well as COM acceleration show oscillations of up to 30 % around the correct value. The reconstructed forces suggest that the slackline can be modeled as a spring with constant stiffness in the lateral direction. In the vertical direction the stiffness varies for larger deflection.

CONCLUSION:

The advantage of our method becomes especially apparent during the flight phase of the motion and when comparing the center of mass and angular momentum dynamics. Additionally, we get reliable information on the interaction forces and the joint torque that allow us to further analyze slackline balancing strategies. Due to numeric complexity and the high amount of variables necessary to formulate the OCP, this method is limited to a few seconds of motion, making it not suitable study long slackline walks. However, we can analyze specific movements connected to balance recovery.

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## CP-BM04 Muscle and tendon function II

### ONLY THREE-WEEK LOW VOLUME NORDIC HAMSTRING EXERCISE TRAINING RESULTS IN AN INCREASE OF THE FASCICLE LENGTH OF THE BICEPS FEMORIS AND THE ISOMETRIC STRENGTH OF THE HAMSTRINGS IN WOMEN

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INTRODUCTION:

There is high prevalence of hamstrings injuries in different types of sports. The Nordic Hamstring Exercise (NHE) is a low-cost and easy achievable method to prevent hamstrings injuries [1] due to an increase of the fascicle length (FL) [2] and the eccentric strength [3]. Most studies on NHE investigated its impact in males and with a high training volume, whereas studies on low volume NHE training [4] and NHE training including women [5] [6] are scarce. Furthermore, FL of the m. biceps femoris (7-8 cm) are often determined by significant extrapolation of ultrasound images from small probe heads (~5cm) which is error-prone [7]. To overcome these shortcomings in the literature, the aim of our study was to examine the effects of a low volume NHE training in female athletes by direct measurements of the FL.

METHODS:

Nine female volleyball players performed the NHE two times per week for three weeks. Each training consisted of 4 sets with 6 repetitions. Before and after the training period the FL, the pennation angle, and the muscle thickness of the m. biceps femoris caput longum was measured with an ultrasonic device (Esaote Mylab 30, 10 cm probe). Furthermore, isometric, concentric (60°/s) and eccentric (45°/s) maximum voluntary contraction (MVC) of the hamstring was measured with a dynamometer (Con-Trex MJ). During the intervention, the

participants documented the degree of muscle soreness on a scale from 0 (no muscle soreness) to 5 (heavy muscle soreness). Paired t-tests were used to analyze the data.

**RESULTS:**

The FL (PRE: 89,7±10,4; POST: 95,6±10,0 mm; P=0.029) and the isometric MVC (PRE: 88,3±15,4; POST: 93,2±12,0 Nm; P=0.049) increased significantly after three weeks while no other significant effects on any of the other measured parameters were observed. Athletes documented hardly any muscle soreness (POST: 2±0,49).

**CONCLUSION:**

We conclude that even a low volume training of the NHE induces structural and functional changes which could help to prevent injuries of the hamstrings in female athletes. Strengths of the study are that we could directly measure the FL, that athletes could easily incorporate the exercise in their training and experienced hardly any muscle soreness. However, we suppose that a longer intervention time is necessary to also increase dynamic strength.

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- 5) Ribeiro-Alvares et al., J Strength Cond Res, 2018
- 6) Seymore et al., Eur J Appl Physiol, 2017
- 7) Franchi et al., Med Sci Sports Exerc, 2020

**PLANTAR FLEXOR MUSCLE-TENDON BEHAVIOUR DURING SPRINT ACCELERATION**

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**INTRODUCTION:**

The compliant nature of distal limb muscle-tendon units is considered suboptimal when positive joint work is required (Biewener, 1998). During sprint acceleration, ankle joint net mechanical work is positive, but ankle joint mechanics also include a phase of negative work after touch-down (Jacobs & van Ingen Schenau, 1992). Therefore, this study aimed to investigate how plantar flexor muscle-tendon behaviour is modulated during fast accelerations requiring net positive work.

**METHODS:**

Eleven female sprinters performed maximum sprint accelerations from starting blocks, while gastrocnemius muscle fascicle length was estimated using ultrasonography. We combined motion analysis and ground reaction force measurements to assess lower limb joint kinematics and kinetics, and to estimate gastrocnemius muscle-tendon unit length during the first two steps of a sprint. Measured variables were resampled to the stance phase and averaged across 3-5 trials. Relevant scalars were extracted and compared using t-tests, and vector trajectories were compared using statistical parametric mapping.

**RESULTS:**

In this study we show that the uncoupling of muscle contractile dynamics from entire joint dynamics is used to generate net positive mechanical work during maximum sprint acceleration. We found that muscle fascicles shortened throughout the first and second stance phase, with greater shortening velocities during the first stance. Fascicle shortening during the ankle dorsiflexion phase after touch-down shows that elastic strain energy may be stored during both steps.

**CONCLUSION:**

Our results show how muscles with high in-series compliance are not only effective springs but can contribute to energy generation during sprint acceleration. Specifically, gastrocnemius fascicle shortening throughout the entire stance phase is enabled by elastic structures, resulting in net positive work during ground contact, but allowing for amplification of joint mechanical power during the plantar flexion phase. These results add to the growing evidence that elastic mechanisms must also be considered in tasks requiring net positive work output (Farris & Raiteri, 2017).

**NON-UNIFORM DISPLACEMENT WITHIN THE ACHILLES TENDON DURING ISOMETRIC CONTRACTION 12 MONTHS AFTER ACUTE ACHILLES TENDON RUPTURE.**

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UNIVERSITY OF JYVASKYLA

**INTRODUCTION:**

Achilles tendon (AT) fascicles originate from the triceps surae muscle [medial gastrocnemius, lateral gastrocnemius, and soleus] (1). Recent studies have provided evidence that non-uniform movement of AT fascicles during muscle contractions is part of healthy tendon function (2), while patients with Achilles tendon rupture (ATR) treated surgically show more uniform inter-fascicle movement (3). The aim of this study was to compare AT internal movement between healthy and injured limbs in non-surgically treated patients 12 months post ATR, and to examine whether patients could be classified into different groups according to AT displacement patterns.

**METHODS:**

Twenty volunteer patients (44.5±9.3 yrs, 175.1±7.6 cm, 81.9±12.7 kg) were tested at 12 months post ATR. Sagittal images of AT were acquired at 50 Hz using B-mode ultrasonography during ramp contractions at 30% of the maximal isometric plantar flexion (MVC) torque of the healthy leg. A speckle tracking algorithm (2) was used to track proximo-distal movement of the tendon tissue at 6 antero-posterior locations. Two way repeated measures ANOVA for peak tendon displacement (6 locations) and limb condition (healthy/injured) was performed. K-means clustering (R clustering package) with the elbow method was used to classify patients according to AT displacement patterns. Results are presented as mean ± standard deviation.

**RESULTS:**

In general, the anterior (deep) part of the tendon displaced more than the posterior (superficial) part. We found a significant interaction of limb condition\*peak tendon displacement ( $F(1.63-61.92)=3.958, p=0.032$ ). The difference in peak displacement between deep and superficial tendon was larger for the healthy ( $1.1±0.97$  mm) than for the injured limb ( $0.53±0.60$  mm,  $p=0.034$ ). For the healthy limb, the cluster analysis separated subjects into 3 groups with different mean peak displacements between groups ( $n=5: 1.4$  mm,  $n=7: 1.2$  mm, and  $n=8: 0.82$  mm,  $p < 0.001$ ), while only 2 groups were formed for the injured limb ( $n=5: 0.81$  mm and  $n=15: 0.44$  mm,  $p < 0.001$ ).

**CONCLUSION:**

The novel finding of three different patterns of AT displacement in the healthy limbs of the subjects may stem from differential anatomy between individuals (1). More importantly, two displacement patterns found in the injured limb may suggest better recovery of some patients, although in the majority of ruptured tendons the internal movement was uniform as shown previously (3). Quantifying internal tendon displacement patterns after ATR may provide a useful method to evaluate the recovery of Achilles tendon functionality. In the present study, ATRs were treated non-surgically, which may partially explain differences from previous studies where surgical treatment was used.

**REFERENCES:**

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**DIFFERENCE OF LOWER LIMB MUSCLE ACTIVITIES BETWEEN LEVEL AND UPHILL SPRINT RUNNING**

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**INTRODUCTION:**

Uphill sprinting is typically used by practitioners and athletes to develop speed, power, and strength in sprinting. The aim of this study was to investigate lower limb muscle activities during uphill and level sprint running and exhibit the practical application of the uphill sprint training.

**METHODS:**

Nine male collegiate sprinters conducted two constant-speed treadmill sprinting at 7.5 m/s in a level and a 5.0% uphill condition. The 47-marker set and surface electromyography were recorded to collect whole-body kinematics data and the muscle activity of the gluteus maximus (Gmax), gluteus medius (Gmed), rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), and gastrocnemius lateralis (GA). The gait cycle was divided into five phases according to the hip and knee kinematics.

**RESULTS:**

The stance time was not affected by the incline ( $p = 0.580$ ,  $d = 0.13$ ), scattering the flight time was significantly shorter in uphill compared to level sprinting ( $p = 0.004$ ,  $d = 1.18$ ). During uphill sprinting, step frequency was significantly higher ( $p = 0.011$ ,  $d = 0.72$ ) and step length was significantly smaller ( $p = 0.017$ ,  $d = 0.70$ ). Two-way ANOVA indicated statically significant interaction effects in each muscle. Activation of the Gmax muscle in uphill was significantly greater during the early stance phase ( $p = 0.047$ ,  $\eta^2 = 0.406$ , 0-5% = 67.9%), and the late recovery phase ( $p = 0.039$ ,  $\eta^2 = 0.432$ , 0-5% = 16.7%) compared to level sprinting. In addition, Gmed muscle was also significantly more activated in uphill compared to level sprinting in the early stance ( $p = 0.016$ ,  $\eta^2 = 0.539$ , 0-5% = 53.3%), late stance ( $p = 0.035$ ,  $\eta^2 = 0.445$ , 0-5% = 162.4%), and early recovery phases ( $p = 0.037$ ,  $\eta^2 = 0.440$ , 0-5% = 49.4%). Moreover, the RF muscle in uphill was significantly more activated during the early recovery phase ( $p = 0.014$ ,  $\eta^2 = 0.550$ , 0-5% = 28.1%) compared to level sprinting. The BF and GA muscles in uphill sprinting were significantly more activated during the early stance phase (BF:  $p = 0.007$ ,  $\eta^2 = 0.616$ , 0-5% = 59.7%, GA:  $p = 0.048$ ,  $\eta^2 = 0.406$ , 0-5% = 22.5%) compared to level sprinting. There were no significant interaction effects in the VL muscle ( $p = 0.733$ ).

**CONCLUSION:**

We found higher muscle activity in Gmax, Gmed, BF, and GA during the stance phase in uphill compared to level sprinting, but no statistical differences in VL between conditions. Furthermore, higher muscle activation during the early recovery phase was identified in the RF muscle in uphill sprinting, which is the unique profile for uphill sprinting in contrast to low speed uphill running. These results could result from the task (sprinting) and environmental (incline) constraints for the uphill sprinting, and suggest that an inclined surface induces selective lower limb muscle recruitment, which could be used for the practical sprint training.

**MUSCLE SIZE, NEUROMUSCULAR PROPERTIES AND STRENGTH PERFORMANCE**

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**INTRODUCTION:**

Both neural and morphological adaptations have been reported to occur after resistance training (1,2). However, controversy exists about morphological or neuromuscular adaptations are needed for optimizing athletic performance and strength gains (3). Therefore, the objective of this study was to analyse the correlation between muscle strength, neuromuscular properties, and muscle hypertrophy.

**METHODS:**

Sixty-four physically active men (age  $24.1 \pm 4.3$  years, height  $1.75 \pm 0.06$  m, body mass  $75.5 \pm 9.7$  kg) performed the following battery of tests: 1) cross-sectional area (CSA), pennation angle (PA) and fascicle length (FL) of the vastus lateralis (VLA) muscle; 2) tensiomyography of the VLA muscle; 3) maximal isometric force (MIF), maximal rate of force development (RFDmax), and root mean square (RMS) in the squat (SQ) exercise with the knees flexed at 90°; and 4) maximal dynamic strength (1RM) in SQ.

**RESULTS:**

Significant relationships were observed between 1RM and MIF ( $r = .63$ ), RFDmax ( $r = .47$ ), CSA ( $r = .39$ ), and RMS ( $r = .35$ ). Moreover, MIF was related to RFDmax ( $r = .66$ ), CSA ( $r = .27$ ), and RMS ( $r = .37$ ). Significant relationships were also observed between RFDmax and PA ( $r = -.35$ ) and RMS ( $r = .38$ ). Lastly, a significant negative correlation was observed between FL and PA ( $r = -.41$ ).

**CONCLUSION:**

Maximal dynamic and isometric strength are moderately related to muscle hypertrophy and neuromuscular activity. Moreover, "explosive strength" was positively related to neuromuscular activity but negatively related to angle of pennation.

**References:**

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- 2) Blazevich et al., J Appl Physiol, 2007
- 3) Buckner et al., Eur J Appl Physiol, 2017

## ECENTRIC BEHAVIOR OF THE HAMSTRING MUSCLES AND THEIR RELATIONSHIP TO SPRINTING AND JUMPING IN SOCCER PLAYERS USING THE SWING ECCENTRIC HAMSTRING EXERCISE (S.E.H.E)

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### INTRODUCTION:

The Nordic Hamstring Exercise (NHE) is the gold standard for many authors for the prevention and optimization of hamstring muscles (1), although from the anatomical and physiological point of view it has several limitations: I) the gesture has no transfer to the real game actions that occur during the injury mechanism (2), and II) is a very demanding and tiring exercise, which cannot be performed by all players (3). On the other hand, it has been shown that there is no direct relationship between the NHE and the improvement of sprint performance and vertical jump with countermovement (4). Therefore, the objective of this study was to evaluate the eccentric behavior of the S.E.H.E and its relationship with the improvement of sprint and jump performance.

### METHODS:

Nineteen football players of the first Andalusian of the senior and youth category of the province of Granada ( $n = 19$ , age  $20.74 \pm 4.04$ , height  $176.00 \pm 5.41$ , weight  $73.35 \pm 8.91$  and game experience  $11.37 \pm 2.71$  years). Three measurement tests were performed: 1) Test-Retest protocol with kinetic control at three different execution speeds (20, 40 and 60 cm / s eccentric phase, keeping the concentric phase constant at 40 cm / s) using an electromechanical dynamometer (DynaSystem Model Research); 2) 30 meter sprint test using photoelectric cells measuring the passage times every 10 meters (10-20-30 m.); 3) Bosco test battery using the OptoJump device, performing Countermovement Jump (CMJ), Squat Jump (SJ), and Countermovement Jump in dominant and non-dominant leg (CMJ Dom / No Dom) and Horizontal Jump (SH) to through the My Jump 2 application (5). The distribution of the data was verified by the Shapiro-Wilk normality test and the association between variables was calculated using the Pearson correlation coefficient. The JASP software package (version 0.9.1.0, <http://www.jasp-stats.org>) was used for all analyzes. The significance was  $P \leq 0.05$ .

### RESULTS:

The main results of this investigation showed that there is a moderate correlation between the Peak Force (PF) at 60 cm / s compared with the Sprint Media (SM) 10 meters ( $r = 0.492$ ,  $p = 0.032$ ) and the Sprint Media 20 meters ( $r = 0.4621$ ,  $p = 0.047$ ). On the other hand, a high correlation was observed between PF (N) 60 cm / s and CMJ ( $r = 0.59$ ,  $p = 0.008$ ), CMJ No Dom ( $r = 0.56$ ,  $p = 0.013$ ) and SJ ( $r = 0.51$ ,  $p = 0.027$ ), taking the variable reactive force index (RSI) (m / s). As for the horizontal jump, a low correlation was observed with the three execution speeds.

### CONCLUSION:

The SEHE performed at high isokinetic speeds has a high correlation with the performance improvement in the vertical jump with countermovement (CMJ), the vertical jump with counter-movement in the non-dominant leg (CMJ No Dom) and the squat jump (SJ), movements which are directly related to the real game actions that soccer players perform such as the head jump from a standstill (CMJ and SJ) and the head jump in the race (CMJ No Dom). Similarly, there was a moderate correlation with improved performance in the sprint at 10 and 20 meters. On the contrary, there was no relationship with the improvement of the horizontal jump at any of the execution speeds.

## THE IMPACT OF HAMSTRING STRAIN INJURY RISK FACTORS ON SUB-MAXIMAL RUNNING KINEMATICS AND MUSCLE ACTIVATION.

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### INTRODUCTION:

Eccentric hamstring strength (EHS) and bicep femoris fascicle length (BFI) are both modifiable risk factors of hamstring strain injuries (HSIs), while HSI events frequently occur during running. Running kinematics and hamstring activation patterns have been assessed post-HSI, however, the influence of the modifiable risk factors prior to a HSI is unknown. Therefore, the purpose of this study was to identify if the modifiable risk factors influence running kinematics and hamstring activation.

### METHODS:

18 male team sport athletes had resting BF images taken at the mid-point of the BF utilising a 10 cm probe. Relative BFI was estimated using the equation:  $OFL + (h/SIN(PA))/femur$  length, where OFL is the observed BFI, h is the perpendicular distance between aponeurosis and BF end point and PA is the pennation angle. Using a standard warm up, isokinetic EHS was assessed at  $60^\circ \cdot s^{-1}$ . Three maximal eccentric knee flexion efforts were performed with a 60 s rest period. Relative peak torque-angle data was calculated using a custom Excel spreadsheet, once phases outside of the desired angular velocity ( $\pm 1^\circ \cdot s^{-1}$ ) were deleted. On a second occasion, 3D lower limb motion data and BF and semitendinosus (ST) electromyography (EMG) was captured while participants ran at a submaximal speed of  $16 \text{ km} \cdot \text{hr}^{-1}$  for 15-seconds (s), normalised to a 10-s maximal treadmill sprint. Minimum acceptable reliability was determined by  $CV < 10\%$  and  $ICC \geq 0.80$ . Subjects were grouped into low and high-risk using a combination of relative EHS and relative BFI, due to a nearly perfect relationship. Independent t-tests with Bonferroni corrections were performed to reduce type 1 error and to determine differences in the peak values between groups. Cohen's d effect sizes (ES) were calculated to determine the magnitude of differences between groups. Additionally, kinematic and EMG data were time normalised from 0 – 100% of the gait cycle. Likely meaningful differences were determined by plotting 95% confidence intervals to identify non-overlapping areas. An a priori alpha level was set at  $p \leq 0.05$ .

### RESULTS:

Large and significant difference across both limbs ( $ES > 1.2$ ,  $p < 0.05$ ) was observed between groups for peak hip extension, with moderate, yet non-significant ( $ES 0.6-1.2$ ,  $p > 0.05$ ) differences identified between peak knee flexion and change in knee angular velocity. Moderate-large, significant differences were also identified within peak relative BF activation and the BF:ST activation ratio. Likely meaningful differences were observed across the gait cycle, with non-overlapping areas for both hip and knee angle kinematics along with BF:ST activation ratio waveforms.

### CONCLUSION:

The results of this study demonstrate that modifiable risk factors for HSI, could influence running kinematics and activation patterns resulting in differences in running strategy at submaximal speeds. Increases in relative EHS and BFI may result in preferable alterations within the running strategy, potentially reducing risk of HSI occurrence.

**BICEPS FEMORIS MUSCLE STIFFNESS IS RELATED TO FLEXIBILITY BUT NOT TO STRENGTH PARAMETERS IN THE HAM-STRING MUSCLE**

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**INTRODUCTION:**

Muscle performance is positively related to muscle size (1) and tendon stiffness (2). Joint flexibility in the hip correlates with muscle stiffness (3). However, so far it is not yet well understood if and how muscle stiffness is related to muscle performance parameters such as flexibility, isometric and dynamic strength, especially in the hamstring muscles. Therefore, the purpose of this study was to investigate relationships between biceps femoris muscle stiffness (BFS), hamstring flexibility, and knee flexion strength performance. Beside other mechanisms, we assumed, that BFS will be negatively related to hamstring flexibility, but positively related to muscle strength performance.

**METHODS:**

Thirty-four healthy male soccer players (mean (SD); 23.4 (3.5) years, 181.7 (5.2) cm, 80.9 (6.9) kg) volunteered in the study. After a standardized warm up, BFS was measured using shear wave elastography in a supine position and fixed in an isokinetic dynamometer with the hip at 90° and the knee at 120° (180° = anatomical zero). In a similar position with a knee angle of 110°, participants performed maximum isometric voluntary contractions of the knee flexors, which were normalized to body mass (MVCnorm). Moreover, hamstring flexibility was assessed using a Sit-and-Reach test. Additionally, counter movement jump (CMJ) and squat jump (SJ) performance was assessed on a force platform. Kolmogorow-Smirnow tests were used to verify normal distribution. Moreover, Pearson's correlation (Rp) was used to calculate the correlation between the parameters.

**RESULTS:**

We found a moderate negative correlation between hamstring flexibility and BFS (Rp=0.43; P=0.01). However, BFS showed non-significant relation to MVCnorm (rP= - 0.17) or jumping performance (rP(CMJ)= 0.11; rP(SJ)= 0.18).

**CONCLUSION:**

The study revealed that biceps femoris stiffness (BFS) plays an important role for the hamstring flexibility. This finding is similar to the results found by Miyamoto et al (2017). In our study, soccer players with a stiffer biceps femoris muscle demonstrated less hamstring flexibility. On the contrary, BFS was not related to isometric strength or jumping performance. The results indicate that lower muscle stiffness favors flexibility without interfering muscle performance.

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**NON-UNIFORMITIES WITHIN THE MUSCLE-TENDON UNIT DUE TO CONSECUTIVE HIGH STRAIN CYCLIC LOADING**

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**INTRODUCTION:**

Tendons as most other living tissue respond to mechanical loading in order to regulate their homeostasis through altering their material and morphological properties. Exercise-induced improvements in muscle strength are commonly accompanied by an increase in tendon stiffness (1), acting as tendon's protective mechanism to the increased functional demand. Differences between muscle and tendon responsiveness as well as time course of adaptive changes to mechanical stimuli (1,2) may lead to an imbalance within the MTU and place tendon under a higher mechanical demand (i.e. increased tendon strain). In the current study we investigated whether the human Achilles tendon (AT) demonstrates alterations in its mechanical properties in response to frequent daily repetitive cyclic loading and lead to possible non-uniformities within the triceps surae MTU.

**METHODS:**

Eleven young male adults (26±6 yrs) were recruited to a 12 consecutive days resistance exercise intervention with high AT strain cyclic loading (isometric plantarflexion contractions at 90% of MVC as in (1)). Participants exercised with one leg once a day (~24h rest between sessions) and with the contralateral leg three times a day (~2h rest between sessions within day) using the same protocol, the 90% was progressively increased every second day based on the daily MVC. Potential exercise-related changes in triceps surae MTU mechanical properties (maximal AT force, maximal AT strain and AT stiffness) in both legs were determined using synchronized ultrasonography and dynamometry two days before (baseline) and every second day during exercise intervention.

**RESULTS:**

Following 12 consecutive days of high AT strain cyclic loading, the leg exercised three times a day showed a significant (P<0.05) increase in AT maximum strain, along with a resulting decrease in AT stiffness. For the leg trained once a day, a tendency (P=0.07) for increased maximal tendon strain and decreased AT stiffness was detected at day 12. The calculated maximal AT force showed a similar increase (P<0.05) during the 12-day period of exercise in both legs.

**CONCLUSION:**

The current results suggest that the plasticity of the AT may depend on the exercise dose (defined as the total amount of mechanical loading trials experienced over a given exercise period) and that the AT length-tension properties may be more vulnerable to alterations due to frequent high strain cyclic loading compared to tendons experiencing a lower exercise dose. As a result, the AT may not be able to tolerate high mechanical loading during tensile loading which could predispose it to tendon injuries. Nevertheless, the dose-response relationship of tendons experiencing mechanical loading is nonlinear suggesting that a certain threshold in exercise dose needs to be exceeded to cause measurable non-uniformities within the triceps surae MTU.

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### DYNAMIC QUADRICEPS INTERMITTENT FUNCTION TEST: A RELIABILITY STUDY

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#### INTRODUCTION:

Locomotor function relies on lower limbs neuromuscular function, particularly three main components: strength, endurance, and fatigability [1]. The quadriceps intermittent fatigue (QIF) test has been previously developed to evaluate these components through progressive incremental loading with assessment of neuromuscular (central and peripheral) fatigue at each stage using electrical or magnetic stimulation [2]. The original version encompasses isometric contractions; thus it may not be representative of activities of daily living. A more ecological approach would be to use dynamic contractions. Yet, such a test has not been validated, nor its reliability assessed. This is the goal of the present study.

#### METHODS:

13 healthy participants performed the dynamic QIF test on two separate days. The test consisted in performing sets of 100 contractions (0.5 s of contraction, 0.5 s of rest) at 120°/s, with an increment of 10% of concentric MVC after each completed set until exhaustion. Isometric and concentric MVC torque and evoked quadriceps torque in response to electrical and transcranial magnetic stimulations were measured to assess central (voluntary activation) and peripheral (resting twitch amplitude) fatigue before, after each set and at task failure. Indexes of fatigue-induced changes (at task failure) inter-session reliability were assessed through coefficients of variation and intra-class correlation coefficient (ICC3,1).

#### RESULTS:

The dynamic QIF test induced a progressive reduction in isometric and dynamic MVC torque during both sessions (session 1 vs session 2: isometric :  $-32.7 \pm 6.2\%$  vs  $-29.5 \pm 6.3\%$ ; dynamic:  $-19.3 \pm 11.1\%$  vs  $-17.5 \pm 7.4\%$ ). Voluntary activation ( $-4.4 \pm 5.6\%$  vs  $-7.3 \pm 11.8\%$ ) and resting twitch amplitude ( $-52.1 \pm 16.5\%$  vs  $-51.9 \pm 14.3\%$ ) also decreased during both sessions. Inter-session reliability were as follows: reduction in isometric MVC torque (CV:  $13 \pm 8\%$ ; ICC = 0.65), resting twitch amplitude (CV:  $18 \pm 13\%$ ; ICC = 0.72), dynamic MVC torque (CV:  $45 \pm 27\%$ ; ICC = 0.14).

#### CONCLUSION:

The present study aimed at validating the QIF test in dynamic conditions to assess neuromuscular fatigue and its central and peripheral components in more ecological although still local contractions. The reliability was much lower than the original QIF test performed in isometric conditions [2] which questions its utilisation to assess patients and athletes.

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## CP-BM05 Neuromuscular physiology and motor control

### GENDER-SPECIFIC RELATIONS BETWEEN COGNITIVE AND MOTOR SKILLS IN PRE-SCHOOL CHILDREN

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#### Introduction

In recent times, there has been an increased interest in the relationship of cognitive and motor skills in children. Previous studies have identified weak to moderate relations between motor and cognitive skills for this age group (Van der Fels et al., 2015; Bidzan-Bluma & Lipowska, 2018). The aim of this study was to focus on pre-school children and investigate their gender-specific relations of cognitive and motor skills.

#### Method

25 girls and 48 boys aged 3 to 5 years (Mage=4.12 SD=.781) participated in the study. The cognitive skills were measured with the Kaufmann Assessment Battery for Children II (Kabc-2; Kaufmann & Kaufmann, 2015). To assess the motor skills the four tests from the Karlsruher Motoric Screening (KMS; Bös et al., 2004) were used. Correlations were examined applying the bivariate Pearson's correlation.

#### Results

The correlation analysis showed statistically significant large relations (Cohen, 1992) between girls' cognitive skills and the standing long jump ( $r=.572$ ;  $p=.003$ ). For the boys, these results could not be confirmed ( $r=-.076$ ;  $p=.609$ ). Small positive correlations were found between girls' cognitive skills and jumping sideways ( $r=.237$ ;  $p=.276$ ), whereas the results of the boys did not show any relations ( $r=.038$ ;  $p=.806$ ). Significant medium correlations between boys' cognitive skills and stand and reach (sar) ( $r=.454$ ,  $p=.006$ ) and small relations between boys' cognitive skills and one-leg-stand (ols) on the dominant leg ( $r=.179$ ;  $p=.223$ ) were identified. Both relations could not be found for the girls ( $r(\text{sar})=-.034$ ;  $p=.974$ ;  $r(\text{ols})=-.023$ ;  $p=.912$ ).

#### Discussion

The results of this study are in line with the findings of Planinsec (2002). By applying different tests, he demonstrated a positive and significant association between the standing long jump and cognitive skills in girls. According to Planinsec, complex motor tasks with predominant leg movements require higher cortical regulations for girls and therefore may explain these findings. The correlations between girls' cognitive skills and jumping sideways as well as between boys' cognitive skills and stand and reach need further research. Correlations between boys' cognitive skills and one-leg-stand were also investigated by Planinsec (2002). He explained the result with carry-over effects by other motor abilities.

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**EFFECTS OF THREE DIFFERENT MUSCLE CONTRACTION/RELAXATION RATES ON MOTOR-RELATED CORTICAL ACTIVITY AT DISTINCT TORQUES**

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**INTRODUCTION:**

Skilled motor control requires the integration of multimodal sensory information to precisely pace and time the respective muscle activities. With respect to the combined and complex characteristics of sport-specific movement performances, it has been shown that in particular, the transition from muscle contraction to relaxation as well as the rate of force development (RFD) is closely related to oscillatory brain activity. Therefore, in a follow-up study investigating all relevant frequency band oscillations (3-50 Hz), three different RFD conditions were used to compare muscle contraction vs. relaxation at lower distinct torques of maximum voluntary contraction (MVC).

**METHODS:**

Accordingly, synchronized recordings of EEG (32 Ag/AgCl-electrodes mounted over motor-related areas), right-limb EMG (i.e., flexor carpi radialis, FCR) and torque were taken from 15 healthy volunteers during the performance of ten submaximal isometric palmar flexions (i.e., motor tasks) at three different RFD rates, respectively. All participants were asked to reach distinct torque levels (i.e. 20% or 40% MVC) and meet similar muscle relaxation rates (i.e., fast, intermediate or slow).

**RESULTS:**

Main findings showed increased oscillatory activity in fast RFD (in 20% and 40% MVC:  $p < .001$ ) over all frequency bands, whereas decreased activity could be observed during both intermediate and slow RFD (in 20% and 40% MVC:  $p < .001$ ). Moreover, findings reveal a continuously decreasing activity pattern from faster to slower RFD and a return to baseline activity in all conditions after full muscle relaxation.

**CONCLUSION:**

Total motor-related cortical activity (3-50 Hz) tend to desynchronize in slower, proprioceptive demanding motor tasks whereas ballistic movements trigger phase synchronization. The constant activity rebound after full muscle relaxation supports a previously reported idea of an inhibitory baseline (Flüthmann et al. 2019).

Main Question: How oscillatory brain activity coordinates complex muscle activities in consecutive motor tasks.

**References**

Flüthmann, N.; Kato, K.; Bloch, O.; Kanosue, K.; Vogt, T. (2019): Effects of longer vs. shorter timed movement sequences on alpha motor inhibition when combining contractions and relaxations. In: *Experimental Brain Research* 237 (1), S. 101–109. DOI: 10.1007/s00221-018-5401-5.

**LOWER EXTREMITIES' COORDINATION PATTERNS DURING CUTTING MANEUVER AFTER ACL RECONSTRUCTION**

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**INTRODUCTION:**

ACL rupture is the most frequent injury in sports fields caused by intensive movements such as cutting maneuver. The most common treatment is ACLR (ACL-reconstruction) which is a surgical treatment. The main purpose of ACLR is to allow the patients return to the sports fields. However, the most of ACLR patients cannot go back to their sports fields though the surgery is done successfully (2). Many studies have been carried out to find the reason, but the results were confusing (4). The reason of inconsistent study results might be that most of previous the researches were focused on only a single joint. Thus, CRP and CRP variability are suggested to explain the coordination pattern between connected joints (5). Therefore, the purpose of this study was to investigate the differences of lower extremities' coordination patterns during cutting maneuver after ACLR and to suggest scientific rationale for the ACL re-injury prevention and rehabilitation methods.

**METHODS:**

A total of 42 participants, twenty-one ACLR patients ([AG]) who scored over 80 in KOOS and twenty-one males ([CG]), were participated in this study. They were asked to perform 30° and 60° cutting maneuvers ten times each and their movements were captured by eight infrared cameras. CRP and CRP variability were calculated on sagittal plane. Independent t-test was performed to compare between AG and CG and the significant level was set at .05.

**RESULTS:**

As a result, CRP of hip-knee joint in AG was significantly greater than CG in both cutting maneuvers and CRP variability of hip-knee joint in AG was significantly smaller than CG in 60° cutting maneuver ( $p < .05$ ). CRP and CRP variability of knee-ankle showed no significant differences in this study. The greater CRP in AG can be explained as that they have more out-of-phase muscle co-contraction to the opposite direction (3). It can also be demonstrated that AG cannot implement the appropriate strategy for impact absorption. In addition, the smaller CRP variability in AG suggests that they use less variety of strategies during cutting maneuver (1). Furthermore, it can additionally cause a soft tissue injury by the repetitive load.

**CONCLUSION:**

ACLR patients are likely to perform less variety movements and inappropriate coordination patterns of hip-knee joints. These can be the risk factors for ACL re-injury. Therefore, the ACLR rehabilitation should be focusing on restoring the functioning and multi-joints exercising to increase the ability to perform the more desirable strategy, rather than the single joint strength training.

**DOES STRUCTURE OF THE BRAIN PREDICT COGNITIVE PERFORMANCE AT REST AND DURING EXERCISE?**

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THE UNIVERSITY OF ELECTRO-COMMUNICATIONS

**INTRODUCTION:**

Cognitive function is determined by multiple factors. A previous study suggested that higher-fit children showed superior flanker task performance, together with greater volume of basal ganglia [1]. This result suggests that structure of basal ganglia (gray and white matter) is linked with cognitive performance. However, it remains unclear whether structure of basal ganglia is associated with cognitive performance at rest and during exercise in young adults. The purpose of this study was to test if basal ganglia volume and white matter micro-structure are associated with cognitive performance at rest and during exercise in young adults.

**METHODS:**

In this study, we used MRI to collect T1-weighted structural brain images and Diffusion tensor images from 22 participants. The participants performed the Go/No-Go task at rest and after exercise at 40% peak oxygen uptake (VO<sub>2</sub> peak) for 30 min. Cognitive performance was assessed by reaction time (RT), accuracy, and changes in RT in response to exercise ( $\Delta$ RT). We analyzed T1-weighted scans with voxel-based morphometry and measured volumes of caudate nucleus, putamen, globus pallidus and nucleus accumbens. We also used Tract-Based Spatial Statistic in FMRIB Software Library (FSL) to generate mean fractional anisotropy (FA) images and produce mean FA skeleton that represented the centers of all tracts common to the group. Aligned FA, radial diffusivity (RD), axial diffusivity (AD), and mean diffusivity (MD) data were projected onto this skeleton and use FSLmaths to calculate regions of interest (ROI) defined by John Hopkins University (JHU) White Matter Label Atlas of the actual average FA, AD, RD, and MD values.

**RESULTS:**

We found that volumes of left caudate nucleus and left globus pallidus were correlated with RT at rest ( $r = -.53, p < .05$ ;  $r = -.56, p < .05$ , respectively), which indicates that basal ganglia volume is associated with cognitive performance at rest. In contrast, basal ganglia volumes were not associated with  $\Delta$ RT and VO<sub>2</sub> peak.

FA values of the right external capsule was correlated with RT at rest ( $p$ -uncorr  $< .05$ ). JHU Atlas based ROI analysis showed that significant correlations between RT at rest and FA value of the left and right external capsules ( $r = -.49, p = .025$ ;  $r = -.52, p = .015$ , respectively), and between  $\Delta$ RT and FA value of cingulate gyrus right ( $r = -.48, p = .029$ ). There were no significant association of RD with RT,  $\Delta$ RT, and VO<sub>2</sub> peak.

**CONCLUSION:**

Volume of basal ganglia predicts cognitive performance at rest, but not during exercise. Microstructure of white matter may also be linked with cognitive performance.

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**ERGONOMICS DEVICE REDUCING THE LEVEL OF ACTIVATION OF THE CERVICAL ERECTOR SPINAE DURING TRIATHLON CYCLING. A PROOF OF CONCEPT**

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**INTRODUCTION:**

Prolonged tension in the neck muscles leads to neck stiffness, pain and injuries among triathletes after the cycling event (1, 2). We hypothesized that a pull to the forehead by two rims assembled and secured to a head rim and a belly rim, could decrease the level of activation of the cervical erector spinae (CES).

**METHODS:**

In this proof of concept, we examined if the designed ergonomics device named ReliCES placed on the head, with a perpendicular pull to the forehead, can reduce the level of activation of the CES, and thereby reduce discomfort or pain during prolonged bike training in relation to triathlon. A pilot trial was conducted on one triathlete aged 25 years. Prior to cycling, three maximal voluntary contraction tests (MVC) were conducted in isometric condition for surface electromyography (sEMG) normalization. The cycling tests lasted 1 hour and consisted on cycling at 120 bpm with and without the ReliCES device. A 72 hours washout period was given between the two cycling tests to minimize any carry over effect and fatigue. The sEMG signals were measured bilaterally at C4 and C5 on respectively the right and the left side of the vertebral column, with a reference electrode on C7 (3). Root mean square (RMS) values were computed over 1 s epoch and normalized with respect to the maximum voluntary electrical activation of the left and right CES.

**RESULTS:**

The results of the pilot test showed that the levels of activation were lower when the ReliCES was used, i.e. for the right and left CES, RMS decreased respectively from  $12.5 \pm 1.1$  to  $11.6 \pm 1.5$  %MVC and  $12.4 \pm 1.1$  to  $10.3 \pm 1.1$  %MVC. The difference in CES level of activation between the left and right side were respectively 1.8 and 0.6 %MVC.

**CONCLUSION:**

These initial results suggesting that the level of activation of the CES can be reduced are promising. Data from a larger population sample are currently being collected to verify that the ReliCES can effectively reduce the level of activation of CES during cycling in triathlon and thereby reduce discomfort and pain among triathletes.

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(3) Szeto GPY et al., *Manual Therapy* 2009.

**EFFECT OF VIBRATION DURING NEUROMUSCULAR ELECTRICAL STIMULATION ON OCCURRENCE AND MAGNITUDE OF EXTRA FORCE**

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UNIVERSITY JEAN MONNET

**INTRODUCTION:**

NMES-induced isometric contractions may arise from the direct activation of motor axons [i.e. efferent pathway; conventional (CONV) NMES] and/or from the recruitment of motoneurons in the spinal cord through the depolarization of sensory axons (i.e. afferent pathway) [1]. This "extra" contraction, the so-called "extra force (EF)" is favoured by the use of low-intensity, wide-pulse-width and high-frequency stimulation (WPHF) [2]. The combination of vibration applied to the Achilles tendon, known to strongly activate Ia afferents, and wide-pulse low-frequency (WPLF) NMES over the plantar flexor muscles has also been reported to elicit EF of considerable magnitude [3]. Yet it may be hypothesized that combining tendon vibration and WPHF NMES would maximize EF. The aim of the present study was therefore to investigate and compare the occurrence and magnitude of EF during tendon vibration associated with CONV, WPLF or WPHF NMES.

**METHODS:**

NMES-induced isometric plantar flexion force was recorded in 20 healthy young subjects. Stimulation trains were delivered through electrodes placed over the triceps surae muscles. The protocol consisted in 3 stimulation trains of 20 s randomly delivered at different pulse widths and frequencies [CONV (0.05 ms, 20 Hz), WPLF (1 ms, 20 Hz) and WPHF (1 ms, 100 Hz)] either with or without Achilles tendon vibration (100 Hz, 1 mm in amplitude) applied from 2 s after electrical stimulation onset to the end of the stimulation period. Stimulation intensity was set to evoke an initial force level corresponding to 10% maximal voluntary contraction. Increase in force from beginning to

the end of the stimulation was measured. EF was further calculated as the mean ratio between the real and the theoretical force-time integral. Subjects were arbitrarily characterized as responders to EF when this ratio was greater than 1.10.

#### RESULTS:

For both CONV and WPLF NMES, a responder rate to EF of 20% was observed and this was increased to 25% when associated with vibration. For WPHF NMES, we found 65% of responders without vibration and 55% when adding vibration. The EF was significantly greater during WPHF ( $1.27 \pm 0.46$ ) than CONV ( $1.05 \pm 0.10$ ;  $p=0.007$ ) and WPLF ( $1.10 \pm 0.23$ ;  $p=0.043$ ). In responders, force increased by an average of  $5.5 \pm 4.0\%$  (range: 1.1-19.8%) of the maximal voluntary contraction during WPHF NMES trains, regardless vibration application.

#### CONCLUSION:

The occurrence and magnitude reported in this study for NMES only are in accordance with the literature [4]. Both the occurrence and the magnitude of EF during NMES were maximized by the use of WPHF but EF was not potentiated by the application of vibration in any condition. The lack of beneficial effect of vibration on EF contrasts with previous findings [3], potentially due to saturation of the afferent pathways and/or differences in vibration parameters.

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- 2) Dean et al., J Appl Physiol, 2007
- 3) Magalhães et al., J Neuroeng Rehabil, 2010
- 4) Wegrzyk et al., Clin Neurophysiol, 2015

### SPINAL EXCITABILITY DURING THE TMS-INDUCED SILENT PERIOD IN THE RECTUS FEMORIS MUSCLE AT DIFFERENT VOLUNTARY CONTRACTION INTENSITIES.

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UNIVERSITY OF JYVÄSKYLÄ

#### INTRODUCTION:

The duration of the silent period after transcranial magnetic stimulation (TMS) has been understood to reflect the level of intra-cortical inhibition, and can alter e.g. as a consequence of exercise-induced fatigue. However, recent evidence in upper-limbs suggests that the spinal contribution to the silent period is longer than previously reported [1] when efferent excitability was assessed as opposed to indirectly via afferent innervation [2]. The purpose of this study was to assess spinal contribution of the silent period (SP) by inducing lumbar evoked potentials (LEP).

#### METHODS:

Participants ( $n=7$ ) performed brief ( $\sim 5$  s) isometric knee extensions at different intensities (25%, 50% and 75% of the maximal isometric voluntary contraction; MVC). Femoral nerve stimulation elicited a maximal M-Wave and, thereafter, lumbar stimulation was adjusted to elicit LEPs of 50% of the M-wave amplitude [3]. TMS stimulator output was adjusted to induce a SP lasting 200 ms. Lumbar stimulations were delivered at 60, 90, 120 and 150 ms latencies following TMS. An unconditioned, single lumbar stimulus was delivered  $\sim 2-3$  s prior to TMS during each contraction. Five contractions were performed at each contraction intensity and for each latency; giving a total of 60 trials. To avoid fatigue, rest periods were provided after each contraction (30, 45 and 60 s) and between sets of 5 contractions (60, 90 and 120 s) for 25%, 50% and 75% MVC, respectively. Measurement order was randomized.

#### RESULTS:

MEP peak-to-peak amplitude remained stable for all contraction intensities and latencies (25% =  $43 \pm 25\%$ ; 50% =  $46 \pm 26\%$ ; 75% =  $45 \pm 24\%$  of Mmax). Compared to the unconditioned LEP amplitude, LEPs during the silent period at 25% MVC showed significant inhibition at 60 ms ( $-21 \pm 32\%$ ,  $p < 0.001$ ), and significant facilitation at 150 ms ( $+20 \pm 21\%$ ,  $p < 0.001$ ). LEPs at 50% and 75% MVC had significant inhibition at 60 ms (50% MVC =  $-31 \pm 30\%$ ; 75% MVC =  $-28 \pm 32\%$ ,  $p < 0.001$ ) and 90 ms (50% MVC =  $-23 \pm 28\%$ ,  $p < 0.001$ ; 75% MVC =  $-21 \pm 28\%$ ,  $p = 0.001$ ).

#### CONCLUSION:

In the present study, peak-to-peak MEP did not change suggesting the same motor unit pool was activated at different contraction intensities. A facilitation at 150 ms during 25% MVC was shown for the first time and might be due to modifications in Golgi tendon function in response to the relatively large force increase following TMS [4]. The results confirm that there was spinal inhibition during the early phase of the silent period (i.e.  $< 100$  ms) following TMS, regardless of contraction intensity. LEPs quantify spinal excitability by directly stimulating the corticospinal tract, and not being reflective of presynaptic inhibition [1, 2]. This study shows that potentially misleading interpretations regarding the silent period could occur if spinal excitability is not accounted for.

#### References

1. Yacyshyn et al 2016 Exp Brain Res 234:3457-3463
2. Roick et al 1993 Exp Brain Res 94:489-498
3. Škarabot et al 2019 Eur J Neurosci 49:1254-1276
4. Grey et al 2007 J Physiol 581:1:99-105

### THE EFFECTS OF MUSCLE STRETCH ON CORTICOSPINAL EXCITABILITY IN SKILL- AND ENDURANCE-TRAINED ATHLETES

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UNIVERSITY OF JYVÄSKYLÄ

#### INTRODUCTION:

It has been shown that motor cortex is highly dynamic and adapts specifically to different types of motor training. For example, skill-trained athletes have higher capacity for motor cortex plasticity than endurance-trained athletes when the representative area of soleus muscle was studied [1]. In addition, since some differences in proprioceptive processing can be identified, e.g. between different age groups [2], it would be of interest to determine whether muscle stretch induced proprioceptive feedback has differing effects on corticospinal excitability between skill- and endurance-trained athletes.

#### METHODS:

Twelve volunteers (5 endurance-trained and 7 skill-trained subjects, age 20-28) completed the study. Subjects sat on an ankle ergometer with their right leg fixed on the pedal of the ergometer. The right ankle was dorsiflexed passively  $4^\circ$  by the ergometer with the velocity of 3.5 rad/s. Motor evoke potentials (MEP) of right soleus muscle induced by transcranial magnetic stimulation (at 100%, 120%, 140%, 150% of resting motor threshold, rMT) were measured at four different time points: prior to ankle dorsiflexion (onset), at the onset of the short latency reflex (SLR), and 120ms after SLR in both passive (rSLR120) and active (20% MVC contraction = aSLR120) conditions.

#### RESULTS:

The average MEP of the input/output (IO) -curve in SLR was significantly lower in endurance group (7.71%,  $P < 0.05$ ) when compared to skill group. MEPs of rSLR120 were higher than onset at 120%, 140% and 150% of rMT in skill group only (1.7%, 2.0%, 2.2%,  $P < 0.05$ ). MEPs of aSLR120 were significantly higher than rSLR120 and onset in both groups with all intensities. There were no significant differences in the stretch reflex responses between endurance (11% of M-max) and skill (13% of M-max) groups.

**CONCLUSION:**

This study showed lower average MEP of IO curve at the onset of SLR in endurance-trained compared to skill-trained athletes. This is most likely due to lower cortical excitability in endurance-trained athletes [3], because of training-induced adaptation. 120ms after the onset of SLR is sufficient time for cortical-proprioceptive processing. At this timepoint corticospinal excitability was different from the onset in skill-trained athletes only. This suggests that training background can indeed modulate the corticospinal excitability differently at a time point when proprioceptive processing is expected.

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**CHANGES IN MOTOR UNIT BEHAVIOUR AFTER ISOMETRIC EXERCISE IN THE TIBIALIS ANTERIOR MUSCLE WITH AND WITHOUT ARTERIAL OCCLUSION**

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UNIVERSITY OF KENT

**INTRODUCTION:**

The dorsiflexor muscles play an important functional role during locomotion, but are highly fatigue-resistant. We assessed motor unit discharge rate characteristics in the human tibialis anterior muscle before and after exercise with and without arterial occlusion.

**METHODS:**

Eleven healthy male participants ( $26 \pm 6$  years;  $71 \pm 10$  kg;  $178 \pm 5$  cm) performed intermittent submaximal isometric dorsiflexion contractions at 30% maximal voluntary contraction (MVC) with either open (control) or closed circulation (occlusion) until task failure or 30 min, whichever occurred sooner. Ischaemia was induced using a cuff around the thigh inflated at 300 mmHg in order to accentuate the fatigue process. Ramp-and-hold contractions at 30% MVC were performed before exercise and immediately after task failure.

High-density electromyography recordings from the tibialis anterior muscle were decomposed into individual motor unit discharge timings. Mean discharge rate was calculated during the 10 s hold phase of the ramp-and-hold contractions for each identified motor unit before being averaged across the motor unit pool to represent global discharge rate. Student's paired samples t-tests were used to investigate differences between pre and post exercise MU discharge rate in the control and occlusion conditions.

**RESULTS:**

All participants completed 30 min during the control condition and time to task failure was  $5.7 \pm 1.5$  min during the occlusion condition. A 12% reduction in global discharge rate was observed in the occlusion condition ( $14.6 \pm 2.3$  vs.  $12.8 \pm 1.8$  pps,  $P = 0.012$ ). In contrast, no difference in global discharge rate was observed during the control condition ( $14.3 \pm 2.9$  vs.  $14.6 \pm 1.5$  pps,  $P = 0.633$ ).

**CONCLUSION:**

We observed a reduction in the global discharge rate of motor units in the tibialis anterior muscle after fatiguing contractions performed with arterial occlusion. Although fatigue-resistant, the motor unit discharge rate response observed in the tibialis anterior is similar to that of other muscles in conditions where blood flow is compromised.

**VISUAL SEARCH BEHAVIOR OF EXPERIENCED TEAM-HANDBALL GOALKEEPERS WHILE ANTICIPATING THE TRAJECTORY OF PENALTY SHOTS**

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**INTRODUCTION:**

Visual identification and anticipation of an opponent's action intentions is crucial for successful performance in interactive situations such as team-handball penalties. The handball penalty throw (PT) is a shot given to the offense after a defense's foul, and has a very high success rate. Goalkeepers (GKs) are required to make accurate course decisions, but few studies focus GKs and PT. We examined experienced and novice team-handball GKs ability to predict the trajectory of shots in the handball penalties and to identify the experienced GKs strategies on spatial cues.

**METHODS:**

The subjects were seven experienced female college handball GKs ( $21.2 \pm 2$  yrs, experience  $6.8 \pm 6.7$  yrs) and seven novice counterparts ( $19.9 \pm 1.1$  yrs, experience  $2.5 \pm 1.1$  yrs.) The participants were tested individually while standing in front of a large screen (207 cm x 366 cm) at the distance of 3 m. and viewing randomized video-based models of PT. Their task was to predict the trajectory of the penalty-takers incoming shot by verbally indicating its vertical and lateral directionality using one of four given quadrants: upper right, upper left, lower right, and lower left. We applied the progressive temporal occlusion paradigm to investigate how the provision of more information affects perceptual judgments. The stimuli were temporally occluded by one of 5 shot-execution phases; 1) taking ball back, 2) first half of forward arm swing, 3) latter half of forward arm swing, 4) ball release, and 5) follow-through. In addition, by using an eye movement tracking system (Tobii Pro Glasses 2), the participants visual search behaviors were acquired to identify the placement of their gaze on the execution phase.

**RESULTS:**

The results indicated that the experienced GK's were able to anticipate the trajectory of the PT significantly more accurately, and earlier, than could the novices. The experienced GK's had effective strategies to anticipate the trajectory of the PT. The effectiveness was related to the experienced GK's selective use of visual cues acquired from a penalty-takers coordinated motions before the PT was released. The visual search behaviors of the experienced GK's were directed on the shoulder and elbow of the penalty takers non-throwing arm at phase 1 to 2. Having picked up on cues from that, they placed their gaze on the shooters throwing arm at phase 2 to 4. By contrast, novices

watched the shooters face throughout all phases, placing their gaze on the throwing arm at the last minute. In addition, many novice gazes were distributed on the ball and the lower limb, but their specific strategies in doing so were not established.

**CONCLUSION:**

This study suggests that the experienced GKs gained visual clues as to PT trajectory from both arm movements of the PT shooter as the latter holds the ball at the penalty line and begins to execute the PT. Moreover, to pay attention to the face or the ball indicated inefficient visual search behavior for GKs.

**EFFECTS OF FOCUSING ON THE SOUND OF THE BALL IMPACT ON GOLF PUTTING PERFORMANCE**

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**INTRODUCTION:**

The sound of the ball/club impact plays an important role in a golfer's perception (e.g. driving distance and accuracy). Previous research has demonstrated that the adoption of an external focus of attention is preferable for learning motor tasks. However, there is still little known about the effect of "focus attention on sound." This research aimed to clarify the effect of focusing on the sound of the ball impact in enhancing golf putting performance.

**METHODS:**

Twenty-one university student (11 males and 10 females, 19–21 years of age, no previous experience in golf) participated in this study. Participants were asked to putt a golf ball to a target on artificial-turf indoor green (0.9×7.0 m). Two different distance targets were marked by black lines on the putting green at 1.8 and 3.6 m from the ball's starting position. Experimental trial phases constituted familiarization, pre-test, and practice (practice phase consisted of 6 blocks of 20 trials). After the pre-test, participants were randomly assigned to three groups: external focus (EXT), internal focus (INT), and control (CTR) groups. The EXT group was instructed to focus attention on the sounds as the club-head impacts against a ball while performing the putting. The INT group was instructed to focus attention on their arm swinging motion, whilst the CTR group was given no instructions about focus. We calculated the absolute errors of putts (AE) and variable error (VE) to assess putting accuracy and consistency for the pre-test and practice phases.

**RESULTS:**

There was no significant difference between the groups on the pre-test. However, during practice, there was a significant decrease in AE from Block 1 to Block 6 only for the EXT group in target 1.8 m. VE showed no significant difference, however, VE was lower in the EXT group than the INT and CTR groups. There was no significant difference observed for the target 3.6m.

**CONCLUSION:**

The results demonstrated that focusing on the sound of the ball impact enhances putting performance in the 1.8 m. The lower VE in the EXT group suggests that focus on the impact sound enhanced consistent movements of the putter head. It is also suggested the sound characteristics of the ball/club impact, such as tone, loudness, can be useful sources of information to enhance putting performance.

**INFLUENCE OF SEX, LEG DOMINANCE AND ANTHROPOMETRIC DATA IN POSTURAL CONTROL AND PROPRIOCEPTION**

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**INTRODUCTION:**

The postural control includes a wide set of neural input by nervous system, essential to keep a static or dynamic balance. The concept of proprioception, defined as the ability to sense position of a joint in the space, is strictly related to postural control. Both are the key factors for balance, joint stability, coordination and injury prevention. The aim of this study was to evaluate the influence of sex, leg dominance and anthropometric data in postural control and proprioception, using Delos Postural Proprioceptive System (DPPS; Delos, Turin, Italy).

**METHODS:**

A cohort of 24 healthy subjects (24.3±2.6 years), 12 women and 12 men, were involved in the study.

Postural control and proprioception were evaluated through Static Riva test and Dynamic Riva test by mean of DPPS. Static Riva test was performed during single stance on a static board and included 2 tasks with open eyes and 4 tasks with closed eyes. Dynamic Riva test was performed during single stance on a rocking board and included 4 trials without upper limbs restriction and 4 trials with upper limbs restriction. Parameters considered for these tests were Stability Index (SI) and Dynamic Stability Index (DSI), both as a percentage score (0-100%), where 100% is a theoretical task performed with maximum stability. Leg dominance and sex differences were evaluated through t-test. The influence of height and weight was first considered using Pearson's correlation coefficient, then by normalizing the raw data.

**RESULTS:**

No significant differences were found in terms of dominant and non-dominant limbs. Thus, the analysis was performed on the average results of two limbs. Women scores were higher than men in all parameters, significant differences were found on SI open eyes task (92.5% vs 89.3%; p=0.02) and on DSI with restriction (67.9% vs 55.9%; p=0.01). An inverse correlation was found between DPPS indices and both height and weight. Normalizing data by height, the gap between women and men reduced for all the scores except for SI open eyes, in which men had significantly higher scores (50.7% vs 71.8%; p=0.03). Normalizing data by weight, women scores were lower than men in all parameters, significant differences were in SI open eyes (27.8% vs 61.5%; p=0.0002) and SI closed eyes (35.3% vs 60.2%; p=0.010).

**CONCLUSION:**

According to scientific literature, this study did not show any differences between lower limbs during single stance test when performed in static or dynamic condition. A raw analysis of result showed a greater proprioceptive and postural control in female subject. When normalizing, it is clear how anthropometric data influenced and often inverted the first results, thus confirming their crucial role in postural control and proprioception. The role of sex differences remains still unclear and needs further analyses. Future studies could include other assessment instrument (e.g. electromyography, force plates) in order to have a global approach to the topic.

**JOINT ANGLE-DEPENDENT FORCE SENSE OF THE KNEE FLEXORS AND EXTENSORS IN HEALTHY ACTIVE MALES**

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**INTRODUCTION:**

Muscle proprioception is probably the intrinsic factor that has received the least attention among the contributing factors to knee joint injuries [1]. Muscle proprioceptors, namely the muscle spindles and the Golgi tendon organs are mechanically sensitive receptors that provide sensation of the muscle length and tension. Their function, either by contracting a muscle in order to resist muscle stretch or by relaxing one in order to control the tension of an active muscle, is of paramount importance for self-preservation and injury prevention [2]. The aim of this study was to investigate the knee flexors and extensors proprioceptive capability at different knee flexion angles.

**METHODS:**

Ten healthy physical active males were recruited for this study. Testing was performed on seated position with the knee joint at 30° and 90° of flexion. Each participant was instructed (i) to obtain and maintain 10, 20 and 30% of the force produced with a MVIC of the knee flexors and extensors by pushing against an external load-cell for 5-sec while watching (target force, TF) and (ii) reproduce the TF immediately after for 5-sec without watching (reproduction force, RF) the digital readout from the display of a connected force-measuring device. The TF and RF were detected simultaneously with the EMG activity of the rectus femoris (REC), and biceps femoris (BIC) on a computer-software using an electronic marking device. Force sense, and the associated EMG activity of REC and BIC, was determined based on the absolute error (AE) between the force obtained during the last second of the TF and the first second of the RF. The relative error (RE) was also calculated as percentage proportion of AE to TF.

**RESULTS:**

Based on the RE and the associated EMG activity of REC and BIC, the joint angle had a significant effect on the knee muscles force sense, with better knee extensors and flexors force sense at 90° and 30° of knee flexion, respectively, that is when these muscles groups were in a lengthened position ( $p < 0.05$ ). Furthermore, force sense was better when both muscle groups had to obtain a greater TF and hence produce greater tension ( $p < 0.01$ ). A greater AE, however, was more likely to be induced by both muscle groups under the aforementioned condition.

**CONCLUSION:**

Muscle proprioceptive capabilities of the knee flexors and extensors are depended on the joint angle. The better force sense of the knee flexors at 30° compared to the knee extensors suggest that there is (i) an inherent muscle proprioceptive imbalance when the knee joint is more extended and (ii) deviations from this imbalance may lead to knee muscle or joint injury.

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**THE EFFECTS OF TDCS ON ENDURANCE PARAMETERS IN CONFIRMED ATHLETES**

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**INTRODUCTION:**

Fatigue is a multifactorial, complex phenomenon that limits athletes' performances. Transcranial direct current stimulation (tDCS) could be an interesting option to reduce supraspinal fatigue. However, to date, very little research has been done on the effects of tDCS on confirmed athletes. Our objective is to compare the effects of tDCS on endurance performance in confirmed athletes

**METHODS:**

Our study is a randomized, double-blind, cross-over study. 30 men aged between 18 and 30 years old were split into two groups (tDCS week 1 and sham week 2, or sham week 1 and tDCS week 2). All were right handed and footed, and had no positive answer on the TSST screening scale. They came to the University Hospital's Isokinetic Lab twice to undergo a fatiguing protocol (30 maximal concentric repetitions over a 100° flexion amplitude at 180°/s). 20 min of either anodal or sham tDCS, with the anode over C3 and the cathode over FP2. We measured peak torque and work for both quadriceps and hamstrings in the dominant limb.

**RESULTS:**

There were no significant effects of tDCS compared to sham on quadriceps peak torque for the first 10, second 10 and final 10 repetitions (respectively 1,5%, 2% and 4,7% difference) or maximal work (respectively 1,5%, 2,5% and 5%), nor for first 10 repetitions of hamstring peak torque (2,5%) and work (3,6%). However, close to significant effects were seen on the second 10 contractions for peak torque values ( $p = 0,087$ , 4,75%) and significant effects were seen for the peak torque in the final 10 repetitions (7%), the maximal work in the second 10 repetitions (6,4%) and the final 10 repetitions (9%).

**CONCLUSION:**

Significant effects on hamstring fatigue were found after tDCS when compared to a sham treatment. These effects could potentially be explained by reducing supraspinal fatigue, or by decreasing perceived discomfort felt during the protocol.

**EFFECTS OF JUMP TRAINING WITH ELECTROMYOSTIMULATION ON JUMP PERFORMANCE**

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**INTRODUCTION:**

This study investigated the effects on jumping performance of training involving consecutive rebound jumps (RJs) combined with electromyostimulation (EMS) applied to muscles closely involved in jumping.

**METHODS:**

Subjects were 49 healthy men who performed consecutive RJ training 3 times a week for 5 weeks. They were divided into 5 groups based on the muscles to which EMS was applied: no EMS (Non-EMS group), the gastrocnemius (EMSGAS group), the quadriceps femoris (EMSQF group), the hamstrings (EMSHAM group), and all thigh muscles (EMST group). In each training session, all groups performed 3 sets of 10 RJs in week 1, 3 sets of 15 RJs in week 2, 3 sets of 20 RJs in week 3, and 4 sets of 20 RJs in weeks 4 and 5. EMS intensity was set to 10% of the maximal voluntary isometric contraction (MVIC) torque in week 1, 15% in week 2, and 20% in weeks 3-5. Jump heights of the counter-movement jump (CMJ), the drop jump (DJ), and 10 consecutive RJs were measured, along with MVIC torque.

**RESULTS:**

In the EMST group, knee extension (KE), knee flexion (KF), and ankle plantarflexion (APF) torque increased, as did the jump height of all the jump types. The jump height of CMJ and DJ increased the most in all training conditions. In the EMSQF group, MVIC torque and the jump height of all the jump types increased. The increase in KE torque was greater in the EMSQF group than in the EMST group. In the EMSHAM

group, only KF torque and the jump height of DJ increased. Characteristic differences between the EMSQF and EMSHAM groups were observed: The EMSQF group moved their body forward and the EMSHAM group moved it backward during consecutive RJs. In the MSGAS group, APF torque and the jump heights of CMJ and RJs increased. Their jump height of RJs increased the most among all the training conditions. This group reported changes in jumping sensation, such as "very bouncy," "staying in the air," and "like bouncing on a trampoline." In the Non-EMS group, no change in MVIC torque or jump height was observed.

#### CONCLUSION:

The results of this study clearly show that the training effects depended on the muscle(s) to which EMS was applied. Simultaneous application of EMS to all thigh muscles improved the jump performance of all jump types by co-contracting the agonist and antagonist muscles, and application of EMS to the quadriceps femoris and hamstrings may have caused horizontal movement of the body from the action of these muscles on each lower limb joint. Thus, it may be effective to change the muscles to which EMS is applied according to the direction of movement required by particular exercises. Application of EMS to the gastrocnemius muscle may have increased the elasticity of the Achilles tendon, thereby improving jump performance, as indicated by the reported changes in jumping sensation. In conclusion, this study suggests that application of EMS to lower limb muscles during RJs enhances jumping performance, but its mechanism and effects depend on the muscles to which it is applied.

### ELECTROMYOGRAPHIC ANALYSIS OF MUSCLE ACTIVITY FROM THE START TO AFTER 134 SIT-TO-STAND TRIALS IN OLDER ADULTS

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#### INTRODUCTION:

The Sit-to-stand (STS) is a highly demanding functional task that requires muscle activation of the hip, knee and ankle. Repetitive sit-to-stand (rSTS) is an often used protocol to induce fatigue. However, it is unclear how rSTS affects muscle activation amplitude, duration and onset, measured by electromyography (EMG), during ascent and descent phases of STS in older adults. With aging, maximal eccentric force is relatively preserved but more unsteady than concentric force. This difference in eccentric/concentric force might differently affect the EMG activity of ascent and descent phases of rSTS. Therefore, we aimed to examine the effects of rSTS on EMG activation amplitude, onset, and duration during ascent and descent phases in the fresh and late stage of STS in older adults.

#### METHODS:

In a standard chair, healthy older adults (71±3y, n=12) performed rSTS to failure at 0.5 Hz paced by a metronome. Before and after rSTS, we examined maximal voluntary quadriceps isometric force (MVIF), rate of force development (RFD), and perceived exertion (RPE, 6 to 20 Borg Scale). Using accelerometry, the ascent and descent phases of STS were defined. Muscle activation amplitude and onset and duration of the EMG signals were calculated for the plantar flexors, dorsiflexors, knee flexors, knee extensors, and hip stabilizers. EMG data of the first 5 (fresh stage) and last 5 STS (late stage) repetitions were analyzed. Paired t-tests were applied to determine differences in MVIF, RFD, and RPE before and after rSTS task. To determine the effect of Phase and Time (fresh vs. late) on EMG outcomes, we applied a repeated-measures ANOVA.

#### RESULTS:

After 134 STS repetitions, MVIF and RFD decreased by 16% and 20% and RPE increased from 8 to 18 (±2). Phase main effect indicated that muscle activation amplitude of the knee extensors was 50% greater during ascent vs. descent ( $p<0.01$ ). A significant Time main effect indicated that during the late stage of rSTS, muscle activation amplitude of the knee extensors and dorsiflexors decreased by 19% and 29% ( $p<0.01$ ). No Phase or Time main effects or Phase by Time interactions occurred in activation duration and onset (all  $p>0.05$ ).

#### CONCLUSION:

Older adults decreased knee extensors and dorsiflexors muscle amplitude after 134 STS series in both ascent and descent phases. These reductions in knee extensors and dorsiflexor EMG activity after rSTS might be due to fatigue-related decrease in number and change in shape of muscle fiber action potentials, resulting in a decline in MVIF and RFD after rSTS. Metronome guidance of rSTS might have minimized changes in temporal features of EMG (onset and duration). Future studies should compare the effects of rSTS in different age groups and analyze the relationship between the changes in EMG activation due to rSTS series and changes in EMG activation during functional tasks, i.e., gait. These studies would shed light on the rSTS as a fatigue model and the interaction between age and fatigue on gait.

## CP-BM06 Muscle power assessment and intervention

### ASSOCIATION BETWEEN CHANGES IN SERUM AND SKELETAL MUSCLE METABOLOMICS PROFILE WITH MAXIMUM POWER OUTPUT GAINS IN RESPONSE TO DIFFERENT AEROBIC TRAINING PROGRAMS

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#### INTRODUCTION:

Understanding the molecular determinants of the cardiorespiratory fitness trainability in response to standardized doses of exercise has the potential to generate new biomarkers and clarify the biology of adaptation to regular exercise. The aim of this study was to investigate the association between changes in serum and skeletal muscle metabolomics profile with maximal power output (MPO) gains in response to 8-week of continuous endurance training (ET) or high-intensity interval training (HIIT) programs.

#### METHODS:

Eighty healthy, young sedentary adult males (18 to 31 years) were randomized to one of three groups, but 70 have completed the study (>90% of sessions): ET (n=30), HIIT (n=30) and control (CO, n=10). Serum and skeletal muscle samples were analyzed by 600 MHz <sup>1</sup>H-NMR spectroscopy. The metabolomics profile panel yielded 43 serum and 70 muscle reproducible metabolites (intra-class correlation coefficient >0.75; coefficient of variation <25%). Associations of pre to post changes in metabolite concentration levels with MPO trainability were explored within each training program via three analytical approaches: (1) correlations between changes in metabolite concentration levels with MPO gains; (2) differences in metabolite concentration level changes between the lowest (1st; low responders) and highest (3rd; high responders) tertiles of gains in MPO in response to ET and HIIT; and (3) metabolite contributions to the most significant changed pathways



related to MPO gains. The significance level was set at  $p < 0.01$ . To identify the key metabolites of the MPO trainability in each group, the metabolites within the three levels of evidence were analyzed by multiple stepwise linear regression (MSLR) independently to serum and muscle ( $p < 0.01$ ). After, the significant metabolites were retained and analyzed in a combined MSLR model for serum and muscle ( $p < 0.05$ ).

**RESULTS:**

Based on analytical strategies, a panel of 15 serum and 3 muscle metabolites were identified in ET while 6 serum and 3 muscle metabolites in HIIT, all within the three levels of evidence. From these metabolites, the final MSLR model identified that changes in serum glutamine ( $\beta = -0.41$ ,  $p = 0.009$ ) and muscle pyruvate ( $\beta = -0.47$ ,  $p = 0.004$ ) accounted for 42.6% (Adj.  $R^2 = 0.426$ ) of variance in MPO trainability in ET, while changes in serum creatine ( $\beta = -0.36$ ,  $p = 0.023$ ) and muscle glycolate ( $\beta = -0.36$ ,  $p = 0.001$ ) accounted for 56.6% (Adj.  $R^2 = 0.536$ ) in HIIT. Two of 13 significant changed pathways associated with MPO trainability, enriched by the key metabolites in serum or muscle, were similar between ET and HIIT: arginine and proline metabolism and glycine, serine, and threonine metabolism. There were no significant MSLR models with key metabolites in CO.

**CONCLUSION:**

We conclude that MPO gains are negatively associated with changes in different metabolites between ET and HIIT programs, indicative mainly of the regulation of arginine and proline metabolism and glycine, serine, and threonine metabolism. Replication studies are warranted.

**EFFECTS OF A HEAVY VS LIGHT-LOAD POWER-ORIENTED RESISTANCE TRAINING ON A UNILATERAL EXERCISE MODEL OVER THE TRAINED AND UNTRAINED LIMB IN OLDER PEOPLE.**

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**INTRODUCTION:**

Power-oriented resistance training (PRT) has emerged as a superior modality to traditional resistance training advocated by the ACSM and aims to improve muscle and physical function in the older population (1). However, PRT adaptations depending on the load used are poorly understood in this population. Based on previous research in the young population (2), we hypothesized that heavy vs light load PRT would lead to equivalent muscle and physical function adaptations in older adults.

**METHODS:**

Eleven well-functioning older volunteers (4 women;  $71.6 \pm 5.2$  years; SPPB score =  $11.9 \pm 0.3$ ) were requested to complete a 12-week PRT on a unilateral exercise model. One of each participant's legs was randomized to train following a heavy- (HL:  $6 \times 6 \times 80\%$  1RM) or a light-load PRT (LL:  $6 \times 12 \times 40\%$  1RM) on a horizontal leg press exercise, whereas the contralateral leg was not trained (CON). Physical function (SPPB), 1RM and maximal muscle power (Pmax), along with lower limb muscle mass (DXA), were assessed in each leg before (T0) and after the training period (T12). Differences between and within-subjects were determined using non-parametric tests (Wilcoxon and Mann-Whitney).

**RESULTS:**

Significant improvements in Pmax were found in HL (T0:  $127.8 \pm 59.4$ W vs T12:  $151.4 \pm 63.1$ W;  $p = 0.028$ ) and LL legs (T0:  $123.8 \pm 50.8$ W vs T12:  $150.4 \pm 58.8$ W;  $p = 0.043$ ). Regarding 1RM, greater values were shown after both HL (T0:  $71.6 \pm 29.1$ Kg vs T12:  $84.9 \pm 31.9$ Kg,  $p = 0.028$ ) and LL (T0:  $79.1 \pm 22.6$ Kg vs T12:  $91.2 \pm 31.1$ Kg, respectively;  $p = 0.043$ ) training. Whereas CON legs showed no significant changes after the interventions. These changes were not reflected in physical function improvements nor muscle mass for either group. When comparing the changes between HL and CON legs, only significant differences were shown in 1RM ( $16 \pm 6\%$  vs  $5 \pm 6\%$ , respectively;  $p = 0.028$ ). Furthermore, when comparing LL and CON legs, no significant differences were found in any outcomes. Finally, no significant differences were assessed between adaptations in HL vs LL (all  $p > 0.05$ ).

**CONCLUSION:**

In older people undergoing a 12-week power-oriented resistance training programme, positive significant changes in Pmax and RM could be achieved by both heavy- and a light-loads.

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**TRANSLATING RAMP VO2 INTO CONSTANT POWER OUTPUT: A NOVEL STRATEGY THAT MINDS THE GAP**

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**INTRODUCTION:**

This study aimed to model the dissociation in the VO2/power output (PO) relationship between ramp incremental (RI) and constant work rate (CWR) exercise and to develop a novel strategy that resolves this gap and enables an accurate translation of the RI VO2 into a constant power output.

**METHODS:**

Nine young men completed two RI tests (30 and 15 W.min<sup>-1</sup>) and CWR tests at seven intensities across exercise intensity domains. The VO2/PO relationship for RI and CWR exercise was modelled and the dissociation was compared in terms of PO. The accuracy of three translation strategies was tested in the moderate (i.e., zone 1) and the heavy (i.e., zone 2) intensity domain. While strategy 1 comprised a simple mean response time (MRT) correction, strategy 2 and 3 accounted for the loss of mechanical efficiency in zone 2 by applying an extra correction that was based on, respectively, the difference between s2-CWR and s2ramp or the ratio s2/s1.

**RESULTS:**

For all intensities, differences in PO were found between CWR and RI exercise ( $P < 0.001$ ). Overall, these differences were smaller for the 15 W.min<sup>-1</sup> compared to the 30 W.min<sup>-1</sup> protocol ( $P = 0.012$ ). Strategy 1 was accurate for PO selection in zone 1 (bias =  $0.4 \pm 7.3W$ ), but not in zone 2 (bias =  $17.1 \pm 15.9W$ ). Only strategy 2 was found to be accurate for both intensity zones (bias =  $2.2 \pm 14.2W$ ) ( $P = 0.107$ ).

#### CONCLUSION:

This study confirmed that a simple MRT correction works for PO selection in the moderate, but not in the heavy intensity domain. A novel strategy was tested and validated to accurately prescribe a constant PO based on the RI VO<sub>2</sub> response in a population of young healthy men.

## CP-MH01 Diabetes and/or metabolic syndrome

### CARDIORESPIRATORY FITNESS AND CALF CIRCUMFERENCE WITH THE PREVALENCE OF DIABETES: WASEDA'S HEALTH STUDY

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#### INTRODUCTION:

Reduced endurance capacity and loss of muscle mass are associated with the incidence of diabetes. Cardiorespiratory fitness (CRF) is an index of whole-body metabolic capacity. Calf circumference (CC) is an index of muscle mass. However, limited data are available on the relationship of CRF, CC and the prevalence of diabetes. This cross-sectional study was to investigate the independent and joint relationships of CRF and CC with the prevalence of diabetes among men in WASEDA'S Health Study.

#### METHODS:

597 men participated in this study. The prevalence of diabetes was investigated using questionnaires and blood tests. CC was divided into two groups according to previous studies. Odds ratios (ORs) and 95% confidence intervals (CIs) for the prevalence of diabetes were obtained using logistic regression models while adjusting for age, body mass index, physical activity, family history of diabetes, smoking, and alcohol intake.

#### RESULTS:

44 participants had diabetes. Using lower CRF and CC as references, ORs (95% CIs) for the higher CRF and CC were 0.55 (0.24–1.28) and 0.64 (0.23–1.77), respectively. Using lower CRF with lower CC group as references, ORs (95% CIs) were 0.47 (0.16–1.39) for the lower CRF with higher CC group, and 0.31 (0.10–0.99) for the higher CRF with higher CC group, respectively.

#### CONCLUSION:

These results suggest that higher CRF and CC are associated with a lower prevalence of diabetes. Furthermore, the combination of the higher CRF and higher CC is associated with the lowest prevalence of diabetes.

### AEROBIC EXERCISE TRAINING REDUCES SERUM ANGIOPOIETIN-LIKE PROTEIN 2 LEVELS IN OVERWEIGHT AND OBESE MEN.

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#### INTRODUCTION:

Obesity has become a major health concern globally and is closely linked to many clinical complications, including insulin resistance, hypertension and cardiovascular disease. Increasing evidence indicates that obesity is linked to chronic and systemic inflammation that is important in the pathophysiology of many obesity-associated disorders. Angiotensin-like protein 2 (ANGPTL2) is a pro-inflammatory adipokine that is upregulated in obesity and plays a role in the progression of diabetes, atherosclerosis and cardiovascular diseases. It has been reported that aerobic exercise is effective in reducing levels of various pro-inflammatory biomolecules in obese individuals. However, the effects of aerobic exercise training on ANGPTL2 in obese individuals remains unclear. Thus, the purpose of the present study was to examine the effect of aerobic exercise training on serum ANGPTL2 levels in overweight and obese men.

#### METHODS:

Twenty overweight and obese men (age,  $49 \pm 10$  years; body mass index,  $27.4 \pm 2.2$  kg/m<sup>2</sup>) completed a 12-week aerobic exercise training program (60-80%HR<sub>max</sub>, 30-60 min/day, 3 days/week). We measured serum ANGPTL2 levels and categorized the physical activity levels (inactivity, light, moderate, or vigorous) before and after the exercise program.

#### RESULTS:

After the 12-week aerobic exercise training program, serum ANGPTL2 levels was significantly reduced ( $3.0 \pm 0.6$  to  $2.7 \pm 0.7$  ng/mL,  $p < 0.05$ ). Moderate physical activity time, vigorous physical activity time, moderate to vigorous physical activity time, VO<sub>2peak</sub> and step counts were significantly increased, whereas inactivity time were significantly decreased after intervention. Interestingly, the changes in serum ANGPTL2 levels were negatively correlated with changes in moderate to vigorous physical activity time ( $r = -0.473$ ,  $p < 0.05$ ).

#### CONCLUSION:

We revealed that a 12-week aerobic exercise training reduced serum ANGPTL2 levels in overweight and obese men. In particular, an increase in moderate to vigorous physical activity may be beneficial to reduce circulating ANGPTL2 levels in overweight and obese men.

### PHYSICAL ACTIVITY, CHRONOTYPE AND SLEEP IN METABOLIC SYNDROME: PRELIMINARY DATA

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#### INTRODUCTION:

Metabolic syndrome (MS) is a complex of interrelated risk factors such as abdominal obesity, high blood pressure, dyslipidemia and high fasting glycemia, which increase the possibility of developing numerous chronic-degenerative diseases [1]. Several hypotheses have been postulated to explain the increase in the prevalence of metabolic syndrome, including diet and insufficient physical activity (PA). In addition, in recent years the sleep deprivation [2] and the chronotype [3] have proven to be emerging risk factors for MS.

Aim of the study was to investigate possible relationships between PA levels, chronotype and sleep behaviour in subjects with MS.

**METHODS:**

We recruited 257 adults (150 F; 107 M) with MS in care at Fondazione IRCCS, Istituto Nazionale Tumori, Milan, Italy. All participants underwent anthropometric and blood sample evaluations and filled in: Godin-Shephard Leisure Time Physical Activity Questionnaire (GSLT-PAQ), reduced Morningness-Eveningness Questionnaire (rMEQ) and Pittsburgh Sleep Quality Index (PSQI), to detect PA levels, chronotype and sleep behaviour, respectively. All analyses were performed using the STATA 12 statistical package.

**RESULTS:**

Compared to females, males with MS were more active with a significantly higher GSLT-PAQ score ( $25 \pm 19.4$  vs  $20 \pm 17.5$ , respectively;  $p=0.03$ ). In both genders, E-Type was the most active chronotype even if there were no statistical differences between chronotypes. Both females and males with MS were bad sleeper, but the females showed a significantly higher PSQI score ( $7 \pm 3.4$  vs  $5.4 \pm 3.4$ , respectively;  $p=0.001$ ). In both genders E-Type was the chronotype showing the worst sleep even if there were no statistical differences between chronotypes.

Finally, both females and males were divided on the basis of the severity of MS (3 parameters vs > 3 parameters). E-Types of both genders presented a severe MS compared to the others chronotypes ( $p<0.05$ ). In addition, compared to subjects with mild MS, severe MS seems to be associated with lower levels of PA as well as with a poor sleep quality in both genders even if there were no statistical differences between the two groups.

**CONCLUSION:**

In conclusion, it seems that a hypothetical subject more at risk of MS could be female E-Type with insufficient levels of PA and poor sleep quality. These findings could represent the basis for physical activity interventions aimed at improving lifestyle habits as a primary prevention of MS.

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**ACUTE EFFECTS OF AEROBIC EXERCISE ON POST-PRANDIAL DIPEPTIDYL PEPTIDASE-4 ACTIVITY AND GLYCEMIC CONTROL IN NON-DIABETIC MEN**

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**INTRODUCTION:**

Endocrine functions of dipeptidyl peptidase-4 (DPP4) enzyme includes reducing insulin secretion and glucose transporter type 4 (GLUT4) translocation mainly through the rapid inactivation of the incretin glucagon-like peptide 1 (GLP1). Even though the inactivation of the DPP-4 enzyme has similar effects as aerobic exercise (AE) on glycemic control, there is a lack of evidences regarding the effect of exercise on DPP4 activity. The aim of this study was to evaluate the effect of a single bout of AE on post-prandial DPP4 activity and glycemic control.

**METHODS:**

Fifteen non-diabetic sedentary men (24.9±1.2 years; BMI 21.6±2.82 kg/m<sup>2</sup>; HbA1c 5.5±0.5%; fasting glucose 81.1±9.1 mg/dL) were randomized into two 10-hour fast interventions: (i) 50min of AE; (ii) control (CON; 50min of absolute rest sitting). Plasma DPP4 activity, plasma glucose, insulin and peptide-C concentration were evaluated before and immediately after AE and CON interventions. Thirty min after interventions, a mixed meal tolerance test (MMTT: 479 kcal, 55% carbohydrate, 30% fat and 15% protein) was taken and plasma samples were collected pre-MMTT, 10, 20, 30, 60, 90 and 120min after MMTT to evaluate plasma DPP4 activity, plasma glucose, insulin and peptide-C concentration.

**RESULTS:**

Plasma DPP4 activity decreased post-exercise only for AE intervention (AE: pre, 0.035±0.008 vs post, 0.032±0.009; CON: pre, 0.034±0.008 vs post, 0.033±0.007; FU/min,  $p<0.05$ ). Glucose, insulin and peptide-C concentration increased ( $p<0.05$ ) post-exercise only for AE session. Glucose remained higher than pre-MMTT until 30 min after MMTT for both AE (pre, 74.3±6.8, 30 min after, 84.8±16.3; mg/dL,  $p<0.05$ ) and CON (pre, 75.3±11.8, 30 min after 100.3±24.2; mg/dL,  $p<0.05$ ). Thirty min after MMTT, glucose concentration was higher ( $p<0.05$ ) for CON than AE intervention. Insulin also presented higher concentrations ( $p<0.05$ ) 60 and 120 min after MMTT for CON than AE intervention. Insulin concentration 120 min after MMTT still remained higher than pre-MMTT only for CON intervention (CON: pre, 4.6±2.2, 120 min after, 13.3±8.2; mU/mL,  $p<0.05$ ; AE: pre, 5.2±2.3, 120 min after 6.5±2.8; mU/mL). CON intervention also showed higher peptide-C concentrations ( $p<0.05$ ) 30, 60, 90 and 120 min after MMTT than AE intervention. Peptide-C concentration 120 min after MMTT still remained higher ( $p<0.05$ ) than pre-MMTT for CON and AE interventions. No differences ( $p>0.05$ ) were observed between AE and CON for glucose concentration area under the curve (AUC) during the 120 min after MMTT; however, insulin and peptide-C concentrations AUC were higher ( $p<0.05$ ) for CON. No differences between time or interventions ( $p>0.05$ ) were observed for DPP4 during the 120 min after MMTT.

**CONCLUSION:**

DPP4 activity decreased after AE; however, no post-prandial changes were observed after AE. Although post-prandial blood glucose response being similar with or without AE for non-diabetic men, the return to baseline values after AE is performed with less release of insulin and C-peptide.

**CP-MH02 Parkinson's and Alzheimer's disease****CENTRAL AND PERIPHERAL COMPONENTS OF MUSCLE FATIGUE IN PATIENTS WITH PARKINSON'S DISEASE**

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**INTRODUCTION:**

Muscle fatigue (MF) is one of the most common and disabling symptoms among patients with Parkinsons disease (PD) and has a harmful impact on their quality of life. However, the etiology and the double nature, central or peripheral, of MF in patients with PD is not clear.

Therefore, the aim of this study was to investigate which of the two components of MF, central or peripheral, is exacerbated in patients with PD. We hypothesized PD-induced degeneration of brain structures and functions would primarily affect the central component of MF.

#### METHODS:

Central and peripheral components of MF were measured via interpolated twitch technique in eight non-demented PD patients and seven healthy controls (CTRL) (age: 68±6 yrs). Specifically, the force expressed during maximal voluntary contraction (MVC), electrically-evoked single resting twitch (Qtw) and muscle maximal voluntary activation (MVA) were analyzed before and after a single leg-extension exercise to exhaustion, to quantify the role of both central and peripheral components of MF. During the fatiguing test, ventilatory parameters and femoral blood flow were recorded.

#### RESULTS:

The exercise workload was significantly lower in PD ( $P<0.05$ ), while the time to exhaustion (~5.8 min) was similar between the groups. Fatigue-induced changes in MVC and MVA were similar in PD and CTRL (MVC: ~16%; MVA: ~2%). A significant reduction of Qtw was observed within each group (PD: -43±27%; CTRL: -49±29%). However, for Qtw no significant differences were found between the two groups ( $P>0.05$ ). Femoral blood flow in PD resulted ~54% lower compared to CTRL subjects, but no detectable differences were observed in ventilatory and cardiovascular parameters between both groups ( $P>0.05$ ).

#### CONCLUSION:

Contrary to our hypothesis, the results of this investigation suggest a similar development and partitioning of MF in patients with PD and CTRL. Interestingly, our data showed a reduction of muscle perfusion during the exercise task that likely exacerbate motor limitation in patients with PD.

### **MATT (MOTOR ASSESSMENT TIMED TEST): A NEW TIMED TEST TO ASSESS MOTOR COMPLICATIONS IN MILD TO MODERATE PD PATIENTS**

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#### INTRODUCTION:

Disorders of motor control in Parkinson Disease (PD) encompass a wide range of motor abnormalities (1). Assessment and quantification of axial features are relevant for diagnosis, tracking disease evolution, treatment effects, functional performance and advancing a prognosis in PD population (2). With the aim of responding to the previous studies demands (3) we designed an objective, quick and easy to administer test that assesses motor disturbances related to PD, comprehensively and separately.

#### METHODS:

Twenty-six patients (16 men and 10 women) with idiopathic PD met the inclusion criteria. Participants were tested between 45-90 minutes after their morning dose of dopaminergic medication. MATT consists of three segments (S1, S2 and S3) that assess gait, stability and dual-task ability, respectively and freezing of gait globally. Seventy-eight trials (three each participant) were recorded on digital video with two cameras (Sony RX100 IV) and analyzed with a software (Kinovea 0.8.27 for Windows 10). Moreover, two trained raters evaluated the video off-line. Results were compared with recommended and suggested instruments to assess PD motor complications (3).

#### RESULTS:

Results showed excellent agreement intraobserver (ICC=0.99,  $\alpha=0.99$ ), interobserver (ICC=0.99,  $\alpha=0.99$ ) and good to very good internal consistency (CV from 1.61 to 16.83). The test showed strong correlations with gait instruments: 10 meters walking test ( $r=0.785$ ,  $p<0.01$ ), Tinetti gait section ( $r=0.669$ ,  $p<0.01$ ), MDS-UPDRS-based PIGD ( $r=0.648$ ,  $p<0.01$ ); balance instruments: Tinetti balance section ( $r=0.732$ ,  $p<0.01$ ), Berg Balance Scale ( $r=0.832$ ,  $p<0.001$ ), ABC scale ( $r=-0.758$ ,  $p<0.01$ ); fall risk: history of falls ( $r=0.767$ ,  $p<0.01$ ); fear of falling: FES-I ( $r=0.767$ ,  $p<0.01$ ); disease severity: H&Y scale ( $r=0.625$ ,  $p<0.01$ ); dual task test: TUG under cognitive dual task condition ( $r=0.791$ ,  $p<0.01$ ) and self-evaluation of FOG: Freezing of Gait Questionnaire ( $r=0.675$ ,  $p<0.01$ ).

#### CONCLUSION:

Our results encourage the use of MATT to assess objectively gait disturbances, balance disorders, freezing of gait, dual-task ability and risk of falling in PD population. With the new MATT test, evaluation times can be shortened whilst maintaining reliability and accuracy. We intend to use MATT data to design rehabilitation seasons in the future.

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### **SPORT CLIMBING AND STIGMATIZING SYMPTOMS IN PARKINSON'S DISEASE**

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#### INTRODUCTION:

Sport climbing (SC) has been used to facilitate neurological rehabilitation. Surprisingly, without peer-reviewed studies on the benefits of SC for Parkinson's disease (PD) patients, particularly in relation to stigmatizing features. Here we investigated the effect on stigmatizing symptoms.

#### METHODS:

SC outcomes were evaluated for PD patients ( $n=24$ ) and compared to a matching physically independent active PD group (IAG) ( $n=24$ ). The climbing group followed a 12-week 90 min/week climbing training course. The control group received education based on the WHO guidelines in performing self-supervised fitness. The control group received information material for independent activity and were instructed to follow this WHO guidelines. All patients were evaluated using the with Parkinson's Disease Quality of Life Questionnaire (PDQ-39), truncal posture measurement, and the motor part of the Movement Disorders-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) and the truncal posture measurement before and after the intervention.

RESULTS:(preliminary data):

## CP-MH03 Concussion

SC is a feasible rehabilitation method for PD patients and improves overall clinical symptoms ( $p < 0.001$ ), facial expression ( $p < 0.01$ ) and rest tremor ( $p < 0.01$ ) in the MDS-UPDRS III. Furthermore, posture ( $p < 0.01$ ) and perceived stigma ( $p < 0.05$ ; PDQ-39) ameliorate after the climbing course.

### CONCLUSION:

SC leads to positive effects on stigmatizing symptoms in PD patients and can enrich the existing field of training therapy. It is crucial to develop innovative and motivating strategies for patients suffering from PD to improve their quality of life. SC can enrich the existing field of training therapy.

## SYSTEMATIC REVIEW OF PREDICTIVE VALIDITY OF MOTOR FITNESS AND FLEXIBILITY IN ADULTS AND OLDER ADULTS. THE ADULT-FIT PROJECT.

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### INTRODUCTION:

Cardiorespiratory(1) and muscular(2) fitness are considered powerful health markers, both in adults and older adults(3). Nonetheless, it is still necessary to clarify the predictive value of motor fitness and flexibility on health outcomes in that populations. Therefore, the aim of the present systematic review was to analyze the predictive value of the existing motor fitness and flexibility tests used to detect health outcomes in adults and older adults.

### METHODS:

Two authors systematically searched in electronic databases Web of Science and PubMed until December 2019, using keyword search terms and review of all initial abstracts. Longitudinal cohort studies examining the association between motor fitness and flexibility tests in adults and older adults and future adverse health outcomes were selected. Each study was classified as high, low or very low quality according to quality assessment lists. Three levels of evidence were constructed: strong, moderate and limited evidence. Based on the prior criteria, a final selection of 74 original studies and 3 systematic review or meta-analysis in healthy adults and older adults were finally analysed in the present study. Of them, 71 original studies were classified as high quality studies.

### RESULTS:

There was strong evidence indicating that slower gait speed and impaired balance were predictive of falls, disability in instrumental daily activities, mobility disability, all-cause mortality, institutionalization or hospitalization from 35 years old. Moderate evidence was found for slower gait speed predicting other-causes mortality, Alzheimer and depression in adults and older adults. Moreover, there was also strong evidence indicating that the timed up&go test was predictive of falls from 60 years old. A large number of other field-based motor fitness and flexibility tests presented limited evidence.

### CONCLUSION:

This systematic review provides accumulated evidence supporting that slow gait speed, impaired balance and low performance timed up&go test are significantly associated with elevated risk of adverse health outcomes in both, adults and older adults.

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Key words: physical fitness, range of motion, population health, predictive value of test.

## CP-MH03 Concussion

### AN EPIDEMIOLOGICAL COMPARISON OF MEN'S AND WOMEN'S HEAD, NECK, AND FACE INJURIES AND MECHANISMS IN U.S. RUGBY-7'S

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1: RRIPG-HSS 2: CGPH-NYU 3: HSS 4:AUT/SPRINZ 5: USAR EMPIRE/NEW ENGLAND 6: NRODA, 7: UM-MOI 8: NBA 9:USA BASKETBALL 10:CANTU CONCUSSION CENTER-EH

### INTRODUCTION:

A high incidence of head injuries, including concussions, has been documented in a growing US rugby playing population. However, few studies have focused on describing common risk factors associated with head injuries.

### METHODS:

A prospective epidemiology study using the Rugby Injury Survey & Evaluation (RISE) Report methodology was employed to capture injury data (Lopez et al, 2012), following the rugby consensus statement (Fuller et al., 2007). Injury data over 2010-2016 (42054=adult players, 3481=teams, 7673=USA Rugby-sanctioned rugby-7s matches). Injury incidence (injuries/1000 player-match-hours (ph)), severity and mechanisms at 95% confidence interval rates were calculated.

### RESULTS:

A total of 498 HNF injuries were encountered with an all-injury rate of 16.7/1000ph (men=17.3/1000ph; women=15.5/1000ph; IRR:1.1; CI:0.9-1.4). The most commonly injured site was the head/face (all-injuries=90.8%; time-loss=86.8%) followed by neck/cervical spine (all-injuries=9.2%; time-loss=13.2%).Time-loss injuries occurred similarly among men and women (IRR:1.5; CI:1.0-2.6; P=0.06). Average HNF injury severity was similar between sexes (29.3±32.4 days absent). The most common injury type were concussions (36.7%; 6.1/1000ph) followed by facial lacerations (28.7%; 4.8/1000ph). Concussions were similarly encountered between sexes (IRR:1.0; CI:0.7-1.3), however, women encountered more severity (46.4d) than men 32.1d; P=0.04). Lacerations occurred more often in men than women. (IRR:2.5; CI:1.6-4.1; P<0.01). The tackle (71.5%) was the most common injury event. Men encountered higher injury rates as a result of direct con-

tact with another player ( $P=0.02$ ). Women were more likely to sustain a head, neck, facial injury with impact with the playing surface ( $P=0.03$ ).

#### CONCLUSION:

US rugby-7s players sustained HNF injuries similarly between sexes. Concussion severity was significantly higher among women than men. Significant associations among men were noted with player on player impacts, meanwhile, women were injured at a higher frequency while impacting the playing surface. Identifying HNF injury patterns among sexes will allow evidence for a more effective injury prevention plan in this emerging US collision sport (Lehman et., 2012,) addressing the specific needs of men and women and skill-levels (Hendricks et al., 2014).

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### NO ACUTE IMPACT OF BALL HEADING ON WHOLE-BODY REACTION TIME IN YOUTH ELITE SOCCER PLAYERS

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#### INTRODUCTION:

Soccer heading and its possible short-term and long-term negative effects on brain function and structure have received increasing scientific attention, even leading to a ban on headers in US children's soccer. While it is well known that sports concussion cause prolonged reaction times (RTs) immediately after injury, it is less clear whether and to which extent subconcussive impacts by heading contribute to cognitive dysfunction. Since even less severe blows can instantly deteriorate neurocognitive performance (1, 2), we hypothesized that multiple purposeful headings in short succession slow down whole-body reaction speed. This in turn affects soccer performance, risk of injury and has a potential cumulative effect for neurodegenerative diseases.

#### METHODS:

In a within-subject design, 16 male U15 soccer academy players (age:  $14.5 \pm 0.2$  yrs) completed 5 frontal headers of soccer balls (launched from a ball machine at a distance of 22.5 m and at speeds of 16 m/s) as far as possible in an 100-sec interval and 5 overhead throws in the control condition. Whole-body choice RT (24 pseudo-randomized stimuli) was assessed before and immediately after the 1st, 3rd and 5th header/throw using 6 FITLIGHT poles placed on the ground. In addition, isometric strength of the neck flexors and extensors was tested by a hand-held dynamometer in standardized protocol (3). 2-wks heading exposure, concussion history and sports experience were evaluated through a self-administered questionnaire.

#### RESULTS:

A Condition(2)xTime(4) ANOVA for repeated measures on RTs revealed neither a significant interaction effect ( $p=.718$ ;  $\eta^2=.029$ ) nor main effect for Condition ( $p=.397$ ;  $\eta^2=.048$ ) with  $961 \pm 113$  ms after headings (test 2 to 4) compared to  $975 \pm 96$  ms in the control condition. RT changes ( $-23 \pm 74$  ms) to baseline did not correlate with the heading distances ( $18.3 \pm 4.8$  m) of the preceding headers ( $p>.569$ ;  $r<.154$ ). Both parameters were also not linearly related to the strength of the neck flexors ( $p>.321$ ;  $r<.265$ ) or extensors ( $p>.130$ ;  $r<.395$ ) or their ratio ( $p>.173$ ;  $r<.358$ ). All players reported that they never had a diagnosed concussion.

#### CONCLUSION:

Even though the youth players performed multiple long headers within a short period of time, we found no acute cognitive impairment in terms of whole-body RT performance. Our results are in line with studies that failed to demonstrate a consistent relationship between subconcussive impacts throughout a single season and cognitive changes (4). Since isometric neck strength played no decisive role, one may speculate that it is more important to acquire an appropriate heading technique. This argues for the use of lighter balls in children's soccer instead of just banning heading, especially in the light of potential long-term effects of chronic heading.

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### ASSOCIATION BETWEEN COMT POLYMORPHISM BUT NOT BDNF-AS OR NOS3 AND ELITE RUGBY ATHLETE STATUS.

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#### INTRODUCTION:

Incidence of and recovery from concussion have a substantial genetic component that probably involves the interaction of multiple genes. COMT (rs4680) AA carriers in youth and professional South African rugby athletes (RA) were ~3-fold more likely to have a history of concussion (Mc Fie et al., 2018). Similarly, BDNF-AS (rs6265) AA genotype has been associated with a higher risk of sustaining a concussion and associated with poorer outcomes post-concussion (Dretsch et al., 2016; Narayanan et al., 2016). Lower cerebral blood flow has been reported in NOS3 (rs2070744) C-allele carriers with traumatic brain injury, postulated to negatively affect a concussed individual during recovery (Robertson et al., 2011). As rugby has one of the highest incidences of concussion in sport (Williams et al., 2013), it was hypothesised that COMT AA, BDNF-AS AA and NOS3 CC genotypes would be less prevalent in elite rugby athletes because, previously associated with increased risk, they would be less compatible with achieving elite athlete status.

#### METHODS:

Participants were from the RugbyGene project, comprising elite Caucasian RA (648 men; mean (SD) height 1.85 (0.07) m, mass 101 (12) kg, age 28 (7) yr) competing at an elite level in rugby union ( $n = 550$ ) and rugby league ( $n = 98$ ) in the UK, Ireland, Italy and South Africa. Non-athlete participants (NA) were 803 Caucasian men and women (58% female, height 1.69 (0.10) m, mass 72 (14) kg, age 41 (23) yr). PCR of

genomic DNA was used to determine genotypes using TaqMan probes, then groups were compared using  $\chi^2$  and odds ratio (OR) statistics. Alpha was set at 0.05.

**RESULTS:**

All genotype data were in Hardy-Weinberg equilibrium. For COMT, the risk genotype (AA) was underrepresented in RA (25%) compared to NA (30%) and GG more common in RA (26%) than NA (22%) ( $\chi^2 = 6.129$ ,  $P = .047$ ; GG genotype frequency OR 2.43, 95% confidence intervals (CI) = 1.88-3.22). For BDNF-AS, there were no differences in genotype frequencies between RA and NA (4% AA genotype in both cohorts,  $\chi^2 = .311$ ,  $P = .856$ ). There were also no differences in NOS3 genotype frequencies (16% CC genotype in RA and 17% in NA,  $\chi^2 = 1.040$ ,  $P = .595$ ).

**CONCLUSION:**

The COMT AA genotype is 5% less common in elite rugby athletes than non-athletes. Therefore, carrying at least one rs4680 G allele, perhaps via a lower risk of experiencing concussion, a greater ability to recover from concussions or altered impulsivity and risk-taking behaviour, appears to increase the probability of reaching elite level in a sport with a high risk of concussion.

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**CP-MH04 Immobilisation / Inactivity****PHYSICAL ACTIVITY AND CARDIOMETABOLIC DISEASE RISK PROFILES OF SOUTH AFRICAN WOMEN FROM A LOW SOCIO-ECONOMIC URBAN COMMUNITY.**

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**INTRODUCTION:**

Physical inactivity is associated with an increased risk for cardiometabolic diseases such as cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM). Few studies to date have described the levels and patterns of physical activity (PA) of urban South African (SA) women from an under-resourced and low socio-economic residential area. Therefore, the aims of this study were to characterise PA levels and patterns in urban-dwelling women and, to determine if women who are sufficiently active have a more favourable cardiometabolic disease risk profile compared to those who are insufficiently active.

**METHODS:**

Fifty-one apparently healthy women ( $42 \pm 13$  yrs) underwent the following measurements: PA (Global Physical Activity Questionnaire and accelerometry), body composition and regional fat distribution (DEXA), resting blood pressure (BP), HbA1c, fasting plasma glucose (FPG) and lipid levels.

**RESULTS:**

Less than a third of the women (27.4%,  $n = 14$ ) met the World Health Organisation Global Health Recommendations for moderate to vigorous-intensity PA (MVPA). Although overweight, the sufficiently active sub-group had a significantly lower BMI ( $p = 0.01$ ), FM ( $p = 0.02$ ), appendicular fat mass ( $p = 0.01$ ) and hip circumference ( $p = 0.001$ ), compared to their obese and insufficiently active counterparts. Although no statistically significant group differences were found for any of the cardiometabolic disease risk outcomes ( $p > 0.05$ ), clinically significant differences were observed for diastolic BP, low-density lipoprotein cholesterol, lipoprotein (a) and FPG.

**CONCLUSION:**

Although overweight, women who accumulated  $\geq 30$ -min of MVPA per day presented with more favourable body composition and regional body fat measures, compared to those who did not. The cardiometabolic disease risk among the sufficiently active women was meaningfully lower than those deemed insufficiently active. In an attempt to combat cardiometabolic disease risk for CVD and T2DM among urban and low socio-economic community dwelling women, public health interventions should target domains in which women are already physically active, such as walking briskly for travel- and/or occupational-related activities. Furthermore, public awareness of the health-enhancing benefits associated with meeting MVPA recommendations must be intensified.

**PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOUR PATTERNS IN ACTIVE HEALTHCARE WORKERS ACCORDING TO SEX.**

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UNIVERSIDAD POLITÉCNICA DE MADRID

**INTRODUCTION:**

Traditionally, it has been observed that men show better physical activity (PA) and sedentary behavior (SB) patterns than women [1]. However, recent studies have reported changes in this tendency [2]. The aim of the present investigation was to define 24-hour PA and SB patterns and compare them according to the day of the week and sex in an intentional sample of healthcare workers.

**METHODS:**

After inviting all workers from the Hospital Universitario Fundación Jiménez Díaz in Madrid, 20 active workers were included (60% female;  $37.5 \pm 11.12$  years). They wore a triaxial ActiGraph GT3X accelerometer on their non-dominant wrist for 7 consecutive days. Acceleration was analyzed following the Freedson cut-off points [3]. Percentage of time in SB, light (LPA) and moderate to vigorous physical activity (MVPA) for weekend days and weekdays was described and compared by sex. The ANCOVA used was adjusted by age. Version 25.0 of the SPSS was used for all data analyses. Statistical significance was set at  $p < .05$ .

**RESULTS:**

All of the participants met the international PA guidelines ( $>150$ min/week). Women presented a slightly lower percentage of time in SB and LPA than men in weekend days (SB:  $63.83 \pm 5.45\%$  vs  $64.70 \pm 6.22\%$ ; LPA:  $20.78 \pm 2.75\%$  vs  $21.73 \pm 5.37\%$ , respectively) whereas, in weekdays, SB was slightly higher, and LPA was lower in women than men (SB:  $59.25 \pm 4.24\%$  vs  $58.80 \pm 6.27\%$ ; LPA:  $25.28 \pm 2.20\%$  vs  $26.17 \pm 4.79\%$ , respectively). Regarding MVPA, women reported a higher percentage of time in comparison with men in weekend days (MVPA:  $15.39 \pm 3.74\%$  vs  $13.57 \pm 42.61\%$ , respectively), although this was not observed during weekdays (MVPA:  $14.77 \pm 2.99\%$  vs  $15.03 \pm 3.12\%$ , respectively). None of the results reached statistical significance (all  $P > .05$ ).

**CONCLUSION:**

In the active healthcare workers recruited in the current study, PA and SB do not differ between men and women and type of the day (weekdays and weekend days). In line with recent studies where no differences in PA by sex are observed, the current results suggest continuing exploring specific populations.

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#### **A WALKING PROGRAM SET UP IN COLLABORATION WITH A SPORTS FEDERATION: A STARTER TO LONG-TERM ENGAGEMENT IN PHYSICAL ACTIVITY FOR MOST SEDENTARY OBESE POSTMENOPAUSAL WOMEN.**

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##### **INTRODUCTION:**

Long-term engagement to physical activity (PA) remains a major public health issue (WHO 2010). However, many adults do insufficient PA to maintain good health (Hallal et al., 2012) and obesity might predispose to inactivity (Bauman et al., 2012).

The aim of the study is to examine the effects of a 16-week brisk walking program on engagement in PA two years after the intervention.

##### **METHODS:**

91 sedentary and overweight-to-obese (BMI = 30±5 kg/m<sup>2</sup>) postmenopausal women (61±6 yr) were subjected to a 16-week endurance-training program (3 sessions of 45 min walking/week at 60 % of their heart rate reserve) and 2 years follow-up. Two weekly walking sessions were supervised by a trained exercise leader of the FFEPGV and took place outdoor in green and natural environments close to home. The 3rd weekly unsupervised session was performed according to participants' preferences on sidewalks, streets, forest trails or in parks. Following measurements were performed at both study-periods:

- . Cardiorespiratory fitness (CRF) assessed by the 2-km walking test
- . Body weight, height and waist circumference
- . Fat mass and lean mass determined by bioelectrical impedance
- . Perceived health estimated by a questionnaire using a visual analogue scale (Garnier et al., 2013)
- . Subjects' assiduity registered in an exercise logbook
- . Two years later, participants were asked additional questions about their PA practice.

##### **RESULTS:**

The mean exercise adherence was 77.3±16.6% (i.e., 104 minutes of walking/week), while the mean exercise intensity was 57.8±9.8% of HRR.

Benefits of the walking program were maintained at 2-year follow-up, for the major factors, i.e., the cardiorespiratory fitness, cardiometabolic risk profile and perceived health. Indeed, maintenance of CRF increase (+5.6 mL/kg/min) as well as in body weight (-1.6 kg) and fat mass (-1.4 kg) losses, but not in waist girth reduction. Results from questions asked 2 years later showed that 67 women continued walking, including 49 at least twice a week, and 4 irregularly (less than once a week). Among these 67 women, 18 also regularly practiced another aerobic PA and 25 gymnastics.

Among the 24 women who dropped walking, 9 women regularly practiced other physical activity for more than 1h/week: 5 gymnastic and 4 aerobic PA. Finally, 76 on the 91 follow-up women (84%) remained physically active.

##### **CONCLUSION:**

This walking program set up in collaboration with a sports federation was a starter to long-term engagement in PA for most women. Whether these long-term benefits are related to womens lifestyle changes or to effects per se of the walking program remained to be established. In conclusion, green activity enhances positive responses to exercise and leads to exercise adherence.

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#### **A SIX- MONTH TAILORED TELEPHONE- AND EMAIL-BASED EXERCISE INTERVENTION INCREASED PHYSICAL ACTIVITY LEVELS AMONG INACTIVE ADULTS: A RANDOMIZED CONTROLLED TRIAL**

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UNIVERSITY OF AGDER

##### **INTRODUCTION:**

Physical activity (PA) is an effective tool for primordial prevention (Reis et al. 2012, Eklund et al. 2019), but efforts to increase levels of PA in the general population shows limited success (Reis et al. 2016). Therefore, the purpose was to assess the effect of a six-month tailored telephone- and email-based exercise intervention on PA levels in healthy but physically inactive adults.

##### **METHODS:**

A total of 111 physically inactive adults (40-55 yr) were enrolled in the study. Participants were randomly assigned to an intervention group (IG;n=56) or a control group (CG;n=55). Every two months the IG received tailored exercise recommendations by email or mail (print) and supporting motivational counseling sessions every fortnight, alternatively by email and telephone. The CG received no follow-up during the intervention period. PA (moderate- to vigorous PA and walking) was assessed using the International Physical Activity Questionnaire, short form (IPAQ-SF), at baseline and after the intervention. A total of 89 participants completed both assessments, but 37 participants were excluded due to missing or incomplete answers, leaving 52 cases (47%) to be included in the analyses. (IG:24, CG:28). All personnel involved in the intervention and both assessments were blinded for group allocation. The data was analyzed by per-protocol using the Statistical Program for Social Sciences. A McNemar's-test was used to check for within-group, pre- to post-test changes and a Mann-Whitney U-test was used to check for between-group differences in the change between pre- to post-test. Results are given in median and effect size (r). The significance level was 0.05.

##### **RESULTS:**



Both the IG and the CG showed a within-group increase in PA levels from pre- to post-test (CG: 60minutes/week-160minutes/week, :  $r=0.382$ ,  $p=0.004$ , IG: 130 minutes/week – 345 minutes/week, :  $r=0.557$   $p<0.001$ ). The median change in total PA level from pre- to post-test in the IG of 202.5 min/week, was significantly larger compared to that achieved by the CG of 52.5 min/week ( $r= 0.326$ ,  $p=0.019$ ).

**CONCLUSION:**

Increased PA levels, at any intensity, are associated with a substantial risk reduction of premature mortality in a dose-response manner (Eklund et al. 2019). Thereby, the increase in PA levels reported in this study, indicate that this intervention may be a promising tool in the promotion of PA. However, the data should be interpreted with caution given the lack in valid data and the use of self-report.

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**CP-MH07 Children and adolescents****THE EFFECTS OF A SCHOOL-BASED PHYSICAL ACTIVITY PROGRAMME ON THE FITNESS LEVELS OF CHILDREN WITH MODERATE TO SEVERE SYMPTOMS OF AUTISM SPECTRUM DISORDER**

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**INTRODUCTION:**

Physical inactivity is a major health issue among children with Autism Spectrum Disorder (ASD). The physical activity levels of children with ASD is substantially lower than the daily recommended 60 minutes (Stanish et al., 2017). As a result children with ASD are more likely to be overweight and obese compared to children without ASD (McCoy et al. 2016). Furthermore, children with ASD have considerably lower fitness levels than their peers, including balance, flexibility, aerobic capacity, and muscular strength, power and endurance (Borremans et al., 2010; Pace and Bricout, 2015). Physical activity, in children with ASD, has been proven to lead to significant improvements in body mass index (BMI), balance, flexibility, coordination, and muscular strength and endurance (Srinivasan et al., 2014; Healy et al., 2018). However, the majority of interventions are difficult and expensive to implement and require special equipment, facilities and trained personal. Furthermore, most studies only include children with mild symptoms of ASD. It is unknown whether physical activity would have similar benefits on children with more severe symptoms of ASD. Therefore, the aim of the study is to assess the effects of a school based physical activity on children with moderate to severe symptoms of ASD.

**METHODS:**

Thirty children (5-18 years) with moderate to severe symptoms of ASD, were included. A 16-week school based physical activity programme was implemented 3 days a week. The Modified Eurofit Tests Battery was used to assess fitness levels at baseline, week 8 and week 16. The test battery consisted of weight, height, Stork Balance Test, Sit and Reach, Standing Broad Jump, Handgrip Strength, Sit-Up Test and 10-meter Sprint. BMI was calculated from the height and weight. A repeated measures ANOVA, or non-parametric equivalent, were used for the statistical analysis.

**RESULTS:**

From baseline to week 16 there were significant improvements in the Stork Balance Test (332.9% mean change,  $p=0.000$ ), Sit and Reach (43.30% mean change,  $p=0.000$ ), Standing Broad Jump (45.86% mean change,  $p=0.000$ ), Handgrip Strength (33.15% mean change,  $p=0.000$ ), Sit-Up Test (69.84% mean change,  $p=0.000$ ) and 10-meter Sprint (11.34% mean change,  $p=0.001$ ). Weight significantly increased (3.28% mean change,  $p=0.000$ ) and BMI insignificantly decreased ( $p>0.05$ ). There were significant increases from week 8 and week 16 for balance ( $p=0.000$ ), broad jump ( $p=0.002$ ), flexibility ( $p=0.02$ ) and sit-ups ( $p=0.043$ ).

**CONCLUSION:**

The results reveal that physical activity lead to significant improvements in flexibility, balance, speed, handgrip strength, core strength and lower limb strength and power. Therefore, physical activity can have beneficial effects on the fitness levels of children with moderate to severe symptoms of ASD. As significant improvements were evident between week 8 and week 16, a longer programme may be more beneficial to improve fitness levels.

**PHYSICAL FITNESS LEVELS RELATED TO BODY MASS INDEX IN CATALAN CHILDREN: THE POIBA STUDY**

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*1 FPCEE-BLANQUERNA; UNIVERSITY RAMON LLULL ; 2 AGÈNCIA DE SALUT PÚBLICA DE BARCELONA*

**INTRODUCTION:**

Obesity and inactivity is one of the most important issues in the last decades as well as a low fitness level in children. As it has shown by the ALADINO study (developed by the Spanish Agency of Food Health, 2011), Spanish children between 6-9 year old presented 45,2% of overweight or obesity.

**AIM:**

To analyse the fitness related to health levels of children from the city of Barcelona (POIBA project).

**METHODS:**

3279 children (1634 boys and 1645 girls) with an age of 7-10 yr. old, participated in the study after obtaining their informed assent and their parent's/tutors/legal guardians informed consent. The study was approved by the Clinical Ethics Committee research CEIC- Parc Salut Mar. Weight, height and BMI were obtained. Fitness related to Health field test were performed by all participants: ball throwing, vertical jump, long jump zig-zag running test, 20 m velocity and 20-meter-shuttle-run test (MSRT). Descriptive for all variables were obtained and T-student was applied to compare boys and girls. ANOVA was applied to compare fitness level related to BMI in boys and girls. The level of significance was set at  $p < 0.05$ .

**RESULTS:**

Significant differences ( $p < 0.001$ ) for all the test showed better results in boys. When controlling for BMI, overweight and obese children, both girls and boys, showed significantly ( $p < 0.05$ ) worse results for vertical jump, long jump, 20 m velocity and 20MSRT. Statistical analyses were conducted using SPSS 19.0 (IBM SPSS Statistics, Chicago, IL, USA)

**CONCLUSION:**

Girls showed worse fitness level than the boys. The higher BMI is related to lower fitness level. These results agree with previous ones in other urban zones. It is necessary to increase the physical activity levels in children.

This project was partially funded by the Fondo de Investigación Sanitaria (FIS) PI09/02259, MEC, Spain.

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**BONE STRUCTURAL REFERENCES IN ATHLETE CHILDREN AND YOUTH**

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**INTRODUCTION:**

The influence of sport activity on bone development is known from the former sport anthropological studies, however the need of using athlete references in bone development estimation of athlete children and youth has just emerging in DEXA analysis practice. The main aim of the study was to construct bone mineral density (BMD) and bone mineral content (BMC), also BMD excluding the head (TBLH) references of athletes for the widely used DEXA scanner.

**METHODS:**

Subjects were 1385 athletes, 1019 males and 366 females, 11-20 years of age, who volunteered to participate in this cross-sectional study. The athletes represented several Hungarian sport academies – primarily basketball, football and handball, with smaller numbers for ice hockey and several individual sports: pentathlon, rhythmic gymnastics, swimming, athletics, fencing, kayak, canoe, rowing, wrestling, karate and weight-lifting. Age- and sex- specific means and standard deviations, and selected percentiles (10th, 25th, 50th, 75th, 90th) were calculated for BMD, BMC and TBLH BMD using the LMS chart maker pro version 2.3.

**RESULTS:**

The athletes were grouped into single year chronological age groups with the whole year as the midpoint (11 years = 10.50 to 11.49, etc.). The total BMD of male athletes is considerably higher than the age-specific references for males ( $p < 0.001$  in each age-group). The median BMD curve exceeds the 90th percentiles of the references. The corresponding trend for total BMD among female athletes also indicates higher BMD ( $p < 0.001$  in every age-group with the exception 20 years,  $p = 0.02$ ). The 25th percentile for female athletes is higher than the 90th percentile of the reference. The percentiles for BMC among male athletes are also consistently higher than the references ( $p < 0.001$  in every age-group). The median percentile of the athletes approximates the 90th percentile of the references across the age range except at 12 years when the 25th percentile of the athletes approximates the 90th percentile of reference. The corresponding trends in the BMC of female athletes generally parallel the reference percentiles from 14 years on, and are significantly higher than the references ( $p < 0.001$  in every age-group, with the exception of 13 years,  $p = 0.04$ ). Percentiles of BMD excluding the head (TBLH BMD in male athletes also differ from the references. The percentiles are higher than the references beginning at 11 years ( $p < 0.001$  in every age-group), and the 25th percentiles of the athletes approximate the 90th percentiles of the reference. The trend in TBLH BMD percentiles of female athletes is similar to that noted in males ( $p < 0.001$  in every age-group with the exception of age-group 13,  $p = 0.04$ ).

**CONCLUSION:**

Compared to reference values for the general population, BMD and BMC of the youth athletes were better developed. Comparison of DEXA observations of athletes with reference values for the general population must be done with care avoid potential misinterpretations.

**THE EFFECT OF ADDITIONAL PHYSICAL EDUCATION CLASSES IN LONGITUDINAL STUDY OF JUNIOR SCHOOL AGE CHILDREN**

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UNIVERSITY OF LATVIA

**INTRODUCTION:**

Physical activity benefits are improved motor performance, muscular strength, cardiorespiratory fitness level and energy balance in children that decreases risk of obesity. Unhealthy dietary habits and sedentary lifestyle caused by modern technologies promotes risk for cardiometabolic diseases even in the younger population, thus obesity prevention strategies have the highest priority in public health worldwide. Organized physical activities including extra school-based physical education (PE) lessons during childhood are more likely to form behaviours promoting healthy lifestyle in adulthood, while regular anthropometric measurements and blood tests can serve as inexpensive monitoring tools in early detection of acute and chronic health problems in children.

The aim of the study was to evaluate the potential effect of additional PE lessons on anthropometric measurements, plasma parameters, blood pressure and fitness level in junior school age children.

**METHODS:**

In fall (2017) 105 3rd grade pupils were enrolled in the longitudinal study (convenience sampling); Experimental (EXP; N=59) and Control (CON; N=46) group having 5 vs. 2 \* 40 min PE lessons. The measurements were performed 4 times and the last one took place in the spring of 2020. Blood pressure, anthropometric data as weight and height were measured with standard procedures. Blood tests were determined by E.Gulbis clinical laboratory and included parameters of triglyceride, high density lipoprotein, low density lipoprotein, insulin, glucose level and HOMA-IR index. Fitness level was determined by a 3-minute step test on a standard 30 cm high gymnastic bench. Children were surveyed about physical activity and attitudes towards it. Data were analysed with R-studio.

RESULTS:

In total 33% of enrolled pupils (EXP N=20; CON n=11) were overweight or obese in fall 2017. There were no significant differences between the EXP and CON groups or within the groups in either of the performed anthropometric or biochemical measurements within the 3-year follow up. However, 50,4% of study participants enjoy being active or use every chance to be active as they really adore it. 18,48% prefer being active on average level and only 4,2% admitted that they would better choose a peaceful walking instead of active exercising.

CONCLUSION:

Extra school based PE lessons are highly valued among primary school's children. However, it does not influence anthropometric measurements or biochemical parameters of primary school pupils over a 3-year period.

It has been discussed that a child's health state is influenced during moderate to vigorous physical activity thus low intensity exercise characteristic for PE programs in primary school could explain results of this study. In addition, teachers role in motivating pupils to exercise more strenuously at this age is of importance. Furthermore, healthy lifestyle key factors include not only regular physical activities, but also a healthy diet that plays an important role in a child's physical development.

**ASSOCIATIONS BETWEEN EXECUTIVE FUNCTIONS AND MOTOR ABILITIES OF SCHOOL-AGED CHILDREN**

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INTRODUCTION:

There is still little research examining the relationship between specific executive functions and motor abilities of schoolchildren. This study investigated the relation between different gross motor skills and performance of executive functions in 10-12 year old children.

METHODS:

Schoolchildren (n = 224, 60.7 % boys) from the 5th and 6th grade of a comprehensive school in Germany completed eight gross motor tests according to endurance, strength, speed, coordination, and flexibility. Motor performance expressed as a Z-score was categorized into 5 groups from 1 (deficient) to 5 (excellent). A battery of computerized tasks (Switch Task, 2-Back Task, Corsi Block-Tapping Task and Flanker Task) was used to test executive functions including cognitive flexibility, inhibitory control, visuospatial memory. All participants were compared by age, sex and BMI.

RESULTS:

Results of post-hoc pairwise comparisons showed that executive functions were improved in children with better skills in 20-meter run (Switch Task, p = .04; Flanker Task, p = .02), balance backwards (Switch Task, p = .02; 2-Back Task, p = .03; Corsi Block-Tapping Task, p = .05), lateral jumping (Switch Task, p = .03; Corsi Block-Tapping Task, p = .04), push-ups (Switch Task, p = .03; Corsi Block-Tapping Task, p = .04) and forward bending of the trunk (2-Back Task, p = .01). The endurance performance (6 minutes run) was not related to the executive functions. In general, boys showed better motor performance (p < .001) and visuospatial memory (p < .001) than girls. The impairment of general motor skills increased with higher BMI (p < .001, r = -0.57) and age (p = .008, r = -0.18).

CONCLUSION:

Overall, the findings showed positive associations between aspects of executive functioning and motor abilities. Specifically, coordinative skills correlated with visuospatial memory. Higher BMI and age could be relevant in this context. Given the differences between boys and girls and the small age range studied, future research is warranted to replicate these findings.

**PREDICTING WHOLE BODY AND APPENDICULAR SKELETAL MUSCLE VOLUME USING LIMB CIRCUMFERENCES IN JAPANESE PREPUBERTAL BOYS**

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INTRODUCTION:

It is difficult to easily estimate total and regional skeletal muscle (SM) volume in children. In these circumstances, we developed prediction equations for estimating SM volume and mass in prepubertal children using ultrasonography (Midorikawa et al., British Journal of Nutrition, 2015) and dual-energy X-ray absorptiometry (DXA) (Midorikawa et al., European Journal of Clinical Nutrition, 2017). However, these modalities are not cost-effective nor easy to access in field research. Therefore, we aimed to develop regression-based prediction equations for estimating whole body and appendicular SM volume from measurements of limb circumferences and skinfold thickness using caliper, and investigate the validity of these equations.

METHODS:

In total, 87 healthy Japanese prepubertal boys aged 6-12 years (Tanner stage 1) were divided into 2 groups: the model development group (61 boys) and the validation group (26 boys). Contiguous magnetic resonance images with 1 cm slice thickness and no-gap were obtained from the first cervical vertebra to the ankle joints as reference data. SM volume was calculated from the summation of the digitized cross-sectional areas. Limb circumferences were measured at mid-upper arm, mid-thigh and mid-calf to the nearest 1 mm. Skinfold thickness was measured at posterior upper arm, anterior thigh and medial calf to the nearest 0.5 mm using an Eiken-type skinfold caliper. The girths of upper arm, thigh and calf were corrected for subcutaneous adipose tissue thickness (corrected arm girth: CAG, corrected thigh girth: CTG, and corrected calf girth: CCG, respectively).

RESULTS:

Strong significant correlations were observed between the site-matched SM volume (whole body, arms, thigh and lower legs) measured by magnetic resonance imaging and each corrected girth × standing height in the model development group (R<sub>2</sub>adj = 0.75 - 0.91, p < 0.01, standard error of the estimate [SEE] = 118 - 776 cm<sup>3</sup>). When these SM volume prediction equations were applied to the validation group, the measured whole body (9101 ± 2123 cm<sup>3</sup>) and appendicular SM volume (arms: 832 ± 193 cm<sup>3</sup>, thigh: 3566 ± 917 cm<sup>3</sup>, lower legs: 1187 ± 311 cm<sup>3</sup>) were very similar to the predicted values (whole body: 8982 ± 2107 cm<sup>3</sup>, arms: 832 ± 206 cm<sup>3</sup>, thigh: 3465 ± 867 cm<sup>3</sup>, lower legs: 1175 ± 256 cm<sup>3</sup>). The results of the Bland-Altman analysis for the validation group did not indicate any bias.

CONCLUSION:

These results suggest that the prediction equations using limb circumferences and skinfold thicknesses are precise and accurate for the estimation of whole body and appendicular SM volume in Japanese prepubertal boys.

### HEART RATE VARIABILITY IN CHILDREN AND ADOLESCENTS WITH CYSTIC FIBROSIS AND ITS ASSOCIATION WITH LUNG FUNCTION, AEROBIC FITNESS AND MUSCLE STRENGTH

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#### INTRODUCTION:

Cystic fibrosis (CF) is a genetic disease that affects the expression of the CFTR protein, which is an anionic channel that conducts bicarbonate and chloride through cell membranes. The expression of CFTR has been reported in both the peripheral and central nervous systems, modulating neuronal excitability. Alterations of the autonomic nervous system that controls the heart can result in oscillations of the R-R interval. Therefore, the evaluation of heart rate variability (HRV) may consist in an easy to perform method to early detection of these alterations in CF. Objective: To evaluate the HRV of children and adolescents with CF and to investigate possible associations with lung function, aerobic fitness and peripheral muscle strength.

#### METHODS:

A cross-sectional study was performed on children aged between 6 and 18 years with a confirmed diagnosis of cystic fibrosis. Patients using beta-blockers, atropine, who presented pulmonary exacerbation requiring hospitalization or intravenous antibiotics, or underwent lung transplantation, were excluded. Demographic, clinical and anthropometric data were collected from routine evaluation. HRV, lung function, cardiopulmonary exercise test (CPET) and peripheral muscle strength were evaluated. HRV data was collected during 5 minutes, in rest, lying down and without any body movements. A Suunto clock was used to acquire data and the Kubios software to analyze it. Normal/altered HRV was classified according to Gąsior (1). Muscle strength was evaluated using both the 5 RM test and the handgrip test. Lung function (FEV1 - forced expiratory volume in one second) and CPET (VO2) followed international recommendations. Descriptive analysis, the student t-test and the Pearson correlation test were used ( $p < 0.05$ ).

#### RESULTS:

Twenty-seven patients with CF (20 boys) were included in the study with a mean age of  $12.7 \pm 2.9$  years; mean body weight (z score) of  $-0.66 \pm 1.16$ , mean FEV1 of  $-1.5 \pm 1.5$  (z score) and mean VO2 of  $43.0 \pm 7.98$ . 25.9% had altered values in SDNN, while 18.5% had altered values in LF/HF. When comparisons between patients with normal or altered HRV were performed, no significant differences were found for FEV1 and VO2. When peripheral muscle strength data was compared, the only significant difference found was for bench press strength ( $p = 0.035$ ). No significant correlations were found between HRV variables and FEV1, VO2 and strength variables.

#### CONCLUSION:

Results demonstrated that the majority of patients studied presented normal values for HRV and no association with clinical and exercise variables. We believe the characteristics of the studied sample, including mild/moderate lung function and a high VO2 level may have influenced results.

Reference: Gąsior JS et al. *Front Physiol.* 2018;9:1495.

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### ACUTE EFFECTS OF FOOTBALL PRACTICE ON THE PHYSICAL PERFORMANCE, RESPIRATORY FUNCTION AND BODY COMPOSITION IN PRE-PUBERTAL CHILDREN

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UNIVERSITY OF CASTILLA-LA MANCHA

#### INTRODUCTION:

Football is one of the most practiced sports in the world and has been suggested as an effective strategy to reduce and prevent cardiovascular diseases in adults (1). Research and reviews carried out with high impact sports have shown better levels of bone mineral content and physical condition in football players (2). However, a large number of these studies focus on body composition or physical condition factors analytically and only a small number of studies analyse in a multifactorial way the effects of physical activity on children's health. Therefore, the purpose of this study was to analyse the effects of a recreational soccer program for 8 weeks, on the physical condition, cardiorespiratory health and body composition of pre-pubertal children compared to an age-matched control group that did physical education classes twice a week. The hypothesis was that football practice would improve physical fitness, cardiorespiratory fitness, reduce body fat and increase muscle- and bone mass in pre-pubertal children.

#### METHODS:

The study sample consisted of 40 children ( $9.3 \pm 1.2$  years) were included in the study and divided in two groups; a football group (FG;  $n=20$ ), with a football training frequency of 3 hours a week and a control group (CG;  $n=20$ ). At the baseline and 2 months later the following variables were measured: Physical conditioning was measured using 30-meter sprint, manual dynamometry, counter movement jump (CMJ) and the Course Navette test. Respiratory function was assessed by spirometry (FVC, FEV1, FEV1/FVC and PEF) while body composition (BMC, BMD, Lean mass, Fat mass) was measured using dual energy X-ray absorptiometry. Puberty status for this investigation was classified as prepubertal (stage I) in all children.

#### RESULTS:

The results of physical condition and cardiorespiratory fitness, VO2max improved ( $p < 0.05$ ) in FG with training ( $+2.9$  ml/kg/min; 95% CI: 1.7 to 4.0 ml/kg/min; TE = 0.84;  $p < 0.05$ ) with no change in CG but not in the sprint, CMJ and handgrip. Respiratory function (FVC), increased in FG with training ( $+0.07$  L; 95% CI: 0.01 to 0.12 L; TE = 0.20;  $p < 0.05$ ) with no change in CG. Bone mineral density and content increased ( $p < 0.05$ ) with training in FG and CG.

#### CONCLUSION:

Children who play football have better levels of fitness, especially in VO2max. In relation to the respiratory function, better values have been achieved with football training. Finally, the training group have improved their levels of bone mass, muscle mass and fat mass significantly in the lower extremities. However, in an 8-week training programme the changes with respect to the control group are minimal, due to the stage of development in which the children are at.

## RELATIONSHIPS BETWEEN BODY COMPOSITION, LOWER BODY PHYSIQUE, PHYSICAL FITNESS, MUSCULAR STRENGTH, AND ANAEROBIC CAPACITY IN ADOLESCENT ATHLETES

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### INTRODUCTION:

The anaerobic energy system is a metabolic process that can release explosive power in a short period. Anaerobic power is an essential factor for power athletes and should be increased for efficient performance. The purpose of this study is to evaluate relationships between body composition, lower extremity physique, physical fitness, muscular strength, and anaerobic capacity in adolescent athletes.

### METHODS:

A total of 178 high school athletes (69 boys, 17.4±1.4 yrs, 173.9±8.4 cm 67.4±11.7 kg, 22.2±2.9 kg/m<sup>2</sup>, 12.9±4.4 % of fat; 109 girls, 16.8±1.6 yrs, 161.7±6.0 cm 55.8±7.8 kg, 21.3±2.3 kg/m<sup>2</sup>, 21.7 ± 4.5 % of fat) were examined. They mostly participated in wrestling, judo, ice hockey, soccer, and swimming. Their leg length was 90.0±4.9 and 84.8±3.9 cm and the girth of thigh was 55.2±5.0 and 55.1±4.8 cm for men and women, respectively. Physical fitness was evaluated by standing long jump, the Sergeant jump, and the sidestep. Isokinetic muscular strength (iMS) at 60° and anaerobic power (AnP; peak power, mean power, and fatigue index) was measured. Correlations were evaluated by comparing body composition, lower body physique, and physical fitness to isokinetic muscular strength and anaerobic power. The relationships between iMS and AnP were also evaluated.

### RESULTS:

Height and leg length were correlated with iMS and AnP in both boys and girls ( $p < 0.05$ ). The body weight and the thigh girth were correlated with AnP ( $p < 0.01$ ). The body fat content was negatively correlated with iMS ( $p < 0.05$ ). All physical fitness measures were correlated with iMS and AnP ( $p < 0.05$ ). Positive correlation was found only in boys between the peak power and the extensor during right concentric contraction ( $r = 0.336$ ,  $p < 0.01$ ) and left concentric contraction ( $r = 0.348$ ,  $p < 0.01$ ). The mean power was positively correlated with flexor and extensor in both boys and girls ( $p < 0.05$ ). The fatigue index was negatively related to right eccentric contraction ( $r = -0.332$ ,  $p < 0.01$ ) in boys and right and left eccentric contraction in girls ( $r = -0.255$ ,  $p < 0.01$  and  $r = -0.190$ ,  $p < 0.05$ , respectively).

### CONCLUSION:

In conclusion, the anaerobic performance was correlated with body composition, lower extremity physique and physical fitness in adolescent athletes. The relationships between iMS and AnP were also demonstrated. Performance can be enhanced by systematic training programs to improve an anaerobic capacity in these young athletes.

## RELATIONSHIP BETWEEN BINOCULAR VISUAL FUNCTION AND PHYSICAL FITNESS IN JAPANESE KINDERGARTEN STUDENTS AGED 4–6 YEARS

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### INTRODUCTION:

Low visual acuity is a serious issue in many countries. A survey conducted by the Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT, 2018) revealed that the number of individuals with low visual acuity (less than 20/20) increases at about 6 years of age and continues to increase with age. The survey found that 26.68% of Japanese preschoolers and 34.10% of elementary school students have low visual acuity.

The MEXT reported declines in all kinds of physical fitness in preschoolers, such as running, jumping, throwing, flexibility, agility, and body balance. Some reports have already suggested the relationship between visual function and physical fitness in elementary school and junior high-school students. However, there have only been a few studies conducted in preschool children with remarkable development of the nervous system.

The purpose of this study was to examine the relationship between visual function and physical fitness in kindergarten students. We focused on binocular visual function, the ability to recognise distance, and three-dimensional perception by appropriate coordination of both eyes.

### METHODS:

Forty-six children (aged 4-6 years) who attended kindergarten in Kyoto-city, Japan participated in this study. The indicators of visual function and spatial cognition function were, namely, (1) static visual acuity, (2) depth perception, (3) the plane figure test, and (4) the model movement test. The indicators of physical performance tests were (1) 25-m sprint, (2) ball throwing, (3) ball catching, (4) standing long jump, (5) body supporting endurance time, and (6) 10-times jump sprint. These indicators used MKS motor ability development tests (Sugihara, et al., 2006) to calculate the overall score.

### RESULTS:

There was a weak correlation between static visual acuity and depth perception ( $r = 0.23$ ,  $p = 0.076$ ). A correlation between depth perception and physical performance test scores ( $r = -0.37$ ,  $p = 0.035$ ) was shown, but not between static visual acuity and physical performance test scores. Among the tests of physical performance, the tests found to be related to depth perception were ball throwing ( $r = -0.48$ ,  $p = 0.003$ ), ball catching ( $r = -0.28$ ,  $p = 0.039$ ), and the model movement test ( $r = -0.58$ ,  $p < 0.001$ ).

### CONCLUSION:

These findings indicate that the correlation between depth perception and physical performance was revealed. In particular, skilled movement that requires perception, such as ball throwing and ball catching tests, showed a correlation with depth perception.

In conclusion, the results of this study suggest that depth perception was related to skilled movements that require perception in the 4–6 age range.

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**INTEGRATIVE NEUROMUSCULAR TRAINING TO IMPROVE MOTOR COMPETENCE IN CHILDREN. RELATIONSHIP BETWEEN PERFORMANCE, BASELINE MOTOR COMPETENCE LEVEL AND TIME REQUIRED MOTOR TASK.**

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**INTRODUCTION:**

Intermediate to high levels of Motor Competence (MC) are required for participation in many physical activities (PA) associated with higher levels of performance and health-related physical fitness. To perform the motor skills involved in several sport and PA, mastery of Fundamental Motor Skills (FMS) is necessary, and accuracy and speed execution of those FMS are crucial. Integrated Neuromuscular Training (INT) is a specific methodology that focuses on the development and mastery of FMS and physical fitness. INT consists of general tasks (locomotor, stability and object control fundamental skills) and strength and conditioning tasks (dynamic stability, coordination, strength, plyometrics, speed, agility, and fatigue resistance). We aimed to assess the impact of an INT in MC in children considering the baseline MC level and the time required to perform different motor task

**METHODS:**

In this randomized control trial, 190 children ( $y=7.43 \pm 0.32$ ; 100 girls and 90 boys) were recruited. A group-based INT program in warm up (INT,  $n=97$ ) was compared with group-based conventional warm up in PE lessons (CONT,  $n=93$ ) to test the improvement on MC and FMS over 24 PE lessons. MC level and mastery of FMS were measured using the Canadian Agility and Movement Skill Assessment (CAMSA). Differences across groups were analyzed by independent T-test. A multiple linear regression analysis was performed to identify predictor variables to the change of MC. T-student was used to calculate changes in: MC level, reduction time and mastery of FMS, in relation to baseline MC. Pearson correlation was used to analyze the correlations between changes in those variables, in relation to baseline MC.

**RESULTS:**

The INT program improved MC ( $p<0.001$ ;  $d=0.74$ ), and mastery of FMS ( $p<0.001$ ,  $d=0.52$ ). The independent predictors of MC change were: baseline MC level ( $\beta = -239$ ;  $p<0.001$ ), time spent to perform the task ( $\beta = -.436$   $p<0.001$ ) and participation in the INT program ( $\beta = .332$ ;  $p<0.0001$ ), explaining 43.8% of its variability. L3 (Achieving Level of MC) is the most sensitive level to the INT program regarding increased MC level (L2 6%  $p=.034$   $d=.65$ ; L3 11.5%  $p<0.0001$   $d=1.93$ ). The INT program shows correlations between improvements in MC level in relation to time reduction (L1  $p=.012$ , L2  $p=.048$ , L3  $p=.011$ , L4=.015) and mastery in FMS (L1  $p<0.001$ , L2  $p<0.001$ , L3  $p<0.041$ , L4<0.001). Correlations between time reduction and mastery in FMS ( $p<0.045$ ) can only be observed in INT program participants in L3.

**CONCLUSION:**

Our results showed that an INT program developed as a warm-up in PE lessons, in 7 to 8-year-olds children during primary school, can improve MC and mastery of FMS in all children, independent of the initial MC level. However, the highest improvement in MC was seen in those children with middle baseline MC levels who adapt the time required to perform the task to their mastery FMS. The results suggest that the improvement in MC should be based on the balance in time required to perform the task and mastery of FMS.

**THE "IMOLA ACTIVE BREAKS STUDY": IMPLEMENTATION OF CLASSROOM PHYSICAL ACTIVITY BREAKS INTERVENTIONS**

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**INTRODUCTION:**

Global recommendations for health children set out to accumulate at least 60 min of Physical activity per day. Despite this, global estimates indicate that low percentages of children and adolescents comply with WHO recommendations. Active breaks (AB) are emerging as a promising way of increasing the frequency of total physical activity (PA), and promoting a reduction of time spent in sedentary behaviours. The "Imola Active Breaks Study" is focused on the implementation of classroom Active Breaks (AB) interventions (10min/3 a day for one year) in primary children as a strategy to promote healthy behaviours and reduce sedentary. The study is currently on the phase of active break somministrazione to children. Here we present the preliminary results of the quasi-experimental pre-post study at baseline.

**METHODS:**

Study design: Quasi-experimental pre-post study in primary school children 6-10 years aged, in Imola (Italy). The assessed variables were: functional exercise capacity (6 minute Cooper test 6MCT and 6 minute walking test 6MWT), cardiorespiratory fitness (Shuttle run test-SRT), and dexterity (Harre test). Physical activity level were evaluated through Actigraph accelerometers as percentage of time spent in Moderate to vigorous physical activity (%MVPA).

**RESULTS:**

A total of 163 children meet the inclusion criteria, 11 children were excluded for no consent to participate. A final sample of 152 children were involved in the study: N=110 children in Active Breaks experimental group (AB) and N=42 children in control group (CG).

We analyzed baseline data, using ANOVA to find a possible significant difference between groups. 3-4 grades: 6MCT (AB  $936.1 \pm 144.3$  vs  $884.7 \pm 112.6$ ,  $p=0.1$ ) SRT (AB  $14.8 \pm 1.6$  vs CG  $14.9 \pm 1.3$   $p=0.8$ ) Harre test (AB  $18.2 \pm 3.6$  vs CG  $18.9 \pm 3.5$ ) %MVPA (AB  $3.7 \pm 1.4$  vs CG  $3.6 \pm 1.1$   $p=0.8$ ). 1 grade: 6MWT (AB  $428.4 \pm 76.8$  vs CG  $447.3 \pm 57.5$   $p=0.3$ ) Harre test (AB  $26.5 \pm 6.2$  vs CG  $27.3 \pm 8.7$   $p=0.54$ ) SRT (AB  $19.5 \pm 2.9$  vs CG  $19.7 \pm 5.4$   $p=0.8$ ) %MVPA (AB  $3.34 \pm 1.50$  vs CG  $4.35 \pm 1.48$   $p=0.02$ ). We found a significant Pearson's correlation coefficients between all the Actigraph outcomes and motor tests in 3-4 grades. The %MVPA is positively correlated with 6MCT ( $r=0.44$ ) and negatively correlated with Harre test ( $r=-0.35$ ) and SRT ( $r=-0.27$ ).

**CONCLUSION:**

There are no significant baseline differences between Control group and Active Breaks group, excepted for %MVPA in 1 grades children. The total and % of time spent in MVPA is positive correlated with performance in motor test. Our research hypothesis is that at the end of the "Imola Active Breaks Study", correlations should be more relevant in the AB group.

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Keywords: Active break, Children, physical activity, accelerometer, MVPA, motor tests.

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## CP-MH08 Exercise interventions in elderly populations

### FOUR WEEKS OF LOW-VOLUME HIGH INTENSITY INTERVAL TRAINING (HIIT) IMPROVES CARDIORESPIRATORY FITNESS IN OCTOGENARIANS WITH AGE-RELATED CO-MORBIDITIES

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#### INTRODUCTION:

Declines in cardiorespiratory fitness (CRF [1]) and fat free mass (FFM [2]) with advancing age are linked to increased risk of morbidity and mortality. Furthermore, with rapid increases in lifespan over the past century, come health challenges; none more so than the increasing prevalence of older people living with one or more “sub-clinical” diseases i.e. multi-morbidity. High intensity interval training (HIIT) has been shown to improve CRF and muscle mass in many cohorts, but its effects in the advanced old with co-morbidities is yet undefined.

#### METHODS:

Eighteen men (M) and ten women (W) (aged 82±1y), with at least one systemic disease (as defined by the American Society of Anaesthesiology as grade 2-3) completed 4-wks (3-sessions-week-1, 15-min-session-1) of HIIT immediately after a prior control period of equal duration. Before and after each 4-wk period, participants underwent dual-energy X-ray absorptiometry (DXA) scans, ultrasound of m.vastus lateralis (VL) and [optional] VL biopsies to quantify mitochondrial capacity and content and skeletal muscle protein synthesis (MPS).

#### RESULTS:

In mixed sex octogenarian participants (totalling N=28), 4-wks HIIT augmented CRF as assessed by anaerobic threshold (AT) (12.8±0.5 to 14.0±0.5 ml·kg<sup>-1</sup>·min<sup>-1</sup>, P=0.003) while also increasing whole-body FFM (47±1 to 48±1 kg, P=0.02). In mixed sex cohort analysis, muscle thickness (MT), fascicle length and pennation angle were unchanged. In terms of sex-specific responses, both M and W demonstrated improvements in CRF (M: 13.2±0.5 to 14.3±0.7, P=0.03; W: 11.8±1 to 13.2±0.8 ml·kg<sup>-1</sup>·min<sup>-1</sup>, P=0.02). Conversely, HIIT-induced increases in MT were apparent in W only (M: 2±0.1 to 2±0.1, P=0.8; W: 1.6±0.1 vs. 1.9±0.1 cm, P=0.02). Mechanistically, mitochondrial citrate synthase (CS) activity (52±4 to 68±5 nmol·min<sup>-1</sup>·mg<sup>-1</sup>, P=0.003) and respiratory chain complex II (1.3-fold, P=0.02) and III (1.2-fold, P=0.04) protein abundance increased in all participants after HIIT, with statistically significant increases shown only in W when participants were divided by sex. Finally, in a mixed sex sub-group of participants, HIIT increased VL MPS (i.e. n=9, 1.3±0.1 to 1.5±0.1 %·day<sup>-1</sup>, P=0.02).

#### CONCLUSION:

Fully-supervised HIIT in octogenarians with age-related co-morbidity(ies), yielded no adverse events and was perceived to be agreeable (~90% of participants). The efficacy of HIIT exercise to increase CRF demonstrates physiological ‘trainability’ in the face of advanced age and systemic disease(s). Increases in mitochondrial protein content and MT in women only, may indicate baseline age-related sex differences or distinct exercise adaptations. We illustrate the potential for HIIT to mitigate deficits in CRF and muscle health in advanced age; these are findings which will have wider clinical implications e.g. in a peri-operative setting.

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### LONGITUDINAL EFFECTS OF A HEAVY- VS. LIGHT-LOAD BALLISTIC TRAINING IN OLDER ADULTS: A UNILATERAL EXERCISE MODEL.

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#### INTRODUCTION:

Resistance training (RT) guidelines for older adults are mostly oriented to use heavy loads as they have been postulated to lead superior adaptations in muscle mass and strength compared to light loads RT(1). However, among older adults, evidence have shown that similar adaptations could be achieved independently of the load used when the volume-load is matched (2). Furthermore, most of the evidence related to this topic were not power-oriented based interventions (i.e. executing contractions as fast as possible), which has been shown to induce greater muscle function adaptations than traditional RT (3). We hypothesised that similar training adaptations could be achieved by a heavy- and a light-load RT when both are power-oriented, and the volume-load is matched.

#### METHODS:

After an 8-week control period, eleven well-functioning older participants (5 men, 71.8±4.7 years, SPPB: 11.9±0.3 points) had their lower limbs randomly allocated to complete both, a power-oriented heavy- (HL: 6×6×80% 1RM) and light-load RT (LL: 6×12×40% 1RM). Participants trained twice a week during 12 weeks on a horizontal leg press. Lower limb muscle mass assessment (DXA), 1RM and a force-velocity testing (F0, V0 and Pmax) were performed before the control period (W0), pre- (W8) and post-training (W20). Time (W0 vs. W8 vs. W20) × Load (HL vs. LL) within-subjects’ interactions were evaluated through repeated measures ANOVAs followed by Bonferroni-adjusted paired t-test.

#### RESULTS:

Neither significant changes throughout evaluations nor significant differences between loads were found in lower limb muscle mass (p>0.05). A significant main effect of Time (W0=W8 vs. W20) was observed.

#### CONCLUSION:

In older people, similar muscle function adaptations could be achieved by a heavy- and a light-load RT when both are power-oriented, and the volume-load is matched. Nevertheless, a 12-week power-oriented RT might not be enough to induce significant changes in lower limb muscle mass.

#### ACKNOWLEDGMENTS:

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## RECREATIONAL TEAM HANDBALL PHYSIOLOGICAL SMALL-SIDED GAMES' DEMANDS FOR POSTMENOPAUSAL WOMEN - DIFFERENCES BETWEEN 4V4 AND 5V5 GAME FORMATS

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1:CIAFEL,FADEUP,PORTO,PT;2:SHSC-SDU,ODENSE,DK;3:SSHS-UE,EXETER,UK;4:SUS,SHANGHAI,CN;5:ST-FIGC,FLORENCE,UTV,ROME,IT;6:CIDESD,ISMAI,MAIA,PT;7:CIFI2D,FADEUP,PORTO,PT;8:PORTOSMEDCENTER,PORTO,PT

### INTRODUCTION:

Recreational team handball is an intermittent high-intensity exercise mode (1) able to induce positive health effects in adult formerly trained men (2). However, this exercise mode demands, namely when played as different game formats, are still understudied in other populations. This study aimed at analyzing the physiological demands of recreational team handball played as small-sided games for inactive postmenopausal women.

### METHODS:

Heart rate (HR), blood lactate and rating of perceived exertion (RPE) were analyzed in thirteen postmenopausal women (68.4±5.9 years, stature 159±10 cm; body mass 65.0±9.6 kg; fat percentage 34.8±6.3%; VO<sub>2</sub>peak 27.6±4.0 mL/min/kg) during 1-2 4v4 and 5v5 recreational team handball matches. The matches (34-35 m<sup>2</sup> area/player) were organized in 3x15-min periods, interspersed by 2-min breaks and preceded by a standardized warm-up. The goalkeeper changed every 3 min. Blood lactate was measured at baseline, and end of the 1st and 3rd periods. Participants' global, muscular and respiratory RPE (AU, 0-10 scale) was assessed at the end of the matches. Maximal heart rate (HR<sub>max</sub>) was determined as the highest HR value obtained either in a treadmill test until exhaustion, the Yo-Yo Intermittent Endurance level 1 test or the matches (3).

### RESULTS:

Mean HR during the 4v4 matches was 130±15 b.min<sup>-1</sup> (76±8% of HR<sub>max</sub>) and during the 5v5, 130±15 b.min<sup>-1</sup> (76±6% of HR<sub>max</sub>). Peak HR was 145±14 b.min<sup>-1</sup> (85±6 % of HR<sub>max</sub>) and 148±14 b.min<sup>-1</sup> (87±4% of HR<sub>max</sub>), for the 4v4 and 5v5 game formats, respectively. Time above 80% of HR<sub>max</sub> was 44±37% (21±18 min) for 4v4 and 31±22% (16±12 min) for 5v5 game formats. HR was above 90% of HR<sub>max</sub> for 6±15% (3±7 min) of the time during the 4v4 and 1±4% (1±2 min) during the 5v5 game formats. In 4v4, mean blood lactate was 2.3±0.6 (1.2-3.0) and peak blood lactate was 2.8±0.7 (1.4-3.7) mM. For 5v5, mean and peak blood lactate concentrations were 2.3±0.5 (1.4-3.5) and 2.6±0.7 (1.4-4.1) mM, respectively. For 4v4 and 5v5 games formats, global RPE was 7.2±1.6 (4.0-9.0) and 7.0±1.0 (6.0-8.0), muscular RPE was 7.0±1.7(4.0-9.0) and 6.8±1.0 (5.0-8.0) and respiratory RPE was 7.0±1.6 (4.0-9.0) and 6.8±1.0 (5.0-8.0) AU, respectively. There were no significant differences in HR, blood lactate and RPE between 4v4 and 5v5 game formats (p>0.05).

### CONCLUSION:

Recreational team handball played as 4v4 or 5v5 small-sided games is a high-intensity exercise mode, that could be used for cardiorespiratory enhancement in postmenopausal women.

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## CONTINUOUS COMPARED TO ACCUMULATED WALKING-TRAINING ON PHYSICAL FUNCTION IN SEDENTARY ELDERLY

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### INTRODUCTION:

Many physical activity (PA) guidelines state that PA should be achieved in bouts of at least 10 min to counteract the negative impact of sedentary behaviors (SB) on the physical function of older adults (OAs) (1). In fact, some authors propose that exercise interventions in OA should take account of current PA patterns, aiming to prolong active morning bouts of PA and reducing SB in the afternoon hours (2). The present study aims to analyze the impact of an overground walking interval training (WIT) in a group of sedentary OAs, comparing two different dose-distributions and timing.

### METHODS:

Twenty-three sedentary OAs (71.00±4.10 years; 75.64±13.07 kg; 10 female), participants in this quasi-experimental and longitudinal study, were assigned to two groups of supervised and tailored WIT (3 times a week during the 15 weeks). Continuous (CON) groups trained for 60 min/session always in the morning, while Accumulated (ACC) groups performed exactly the same dose and intensity of exercise, but distributed twice a day (30 min in the morning and 30 more in the afternoon). Intervals and intensities were increased and scheduled considering the rating of perceived effort (RPE 1-10) and complementary Heart Rate monitoring. Repeated Measures ANOVA was conducted to analyze changes in cardiovascular fitness (6 Minute Walk Test), lower limb strength (5 times sit-to-stand), preferred walking speed (PWS), and agility (Timed Up & Go test).

### RESULTS:

Considering the whole sample, pre-post comparison showed a significant effect (p<0.05) of the training in all variables. Furthermore, bonferroni post-hoc comparisons revealed significant (p<0.05) and similar improvements in both groups on cardiorespiratory fitness (CON: d=1.023; ACC: d=1.009), lower limb strength (CON: d=1.151; ACC: d=1.048); and PWS (CON: d=1.573; ACC: d=1.206). Only agility appeared to benefit from the ACC strategy, with a greater difference in the effect size (CON: d=0.485; ACC: d=0.996).

### CONCLUSION:

Our results show that both dose-distribution strategies (of WIT) evoke similar benefits at least in elderly's physical function, so the accumulation of morning / afternoon exercise bouts doesn't appear important beyond total volume of activity when starting physical exercise, as previously suggested (3). Future research is needed to confirm that accumulated exercise produces greater improvements in some functional skills like agility in OAs following WIT, and who could benefit from it.

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**CLUSTER AND TRADITIONAL SET CONFIGURATION: EFFECTS OF A 6-WEEK CONCURRENT EXERCISE PROGRAM IN OLDER ADULTS**

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**INTRODUCTION:**

Approximately 50% of people over 65 years suffer from frailty syndrome in Spain(1), generating an increase in demands and cost of long-term healthcare. Concurrent exercise seems to be one of the best approaches to restore and/or maintain functional performance and reverse frailty. In this sense, resistance training (RT) using cluster set configurations (CT) (distribution of rest between repetitions) has not been well studied yet in older people.

**Aim:** Describe the effects of a concurrent training program using CT configuration in adults aged >70 years on the force-velocity relationship, and its impact on frailty status and physical function.

**METHODS:**

Twenty three frail or pre-frail(2) older adults (15 women; mean age: 82.3 ± 4.7 y; BMI: 27.83±4.3; SPPB: 7.1±2.0) were recruited in a Hospital's Frailty Unit. Patients were assigned to traditional (TT; n=13) or cluster training (CT; n=10). Both groups performed a 6-week concurrent training program (2 sessions/week; ≈45 min/session) that consisted of RT (leg press and plantar flexion exercises) and aerobic exercise on a treadmill. They performed 3-4 sets of 8-14 reps at 30-50% of the maximal isometric force (F0) with focus on power. CT had 10s rest each 2reps and 1min rest inter-sets and TT no intra-sets rest. Aerobic training was based on high intensity interval training (combining habitual and maximal gait speed). Force-Velocity relationship(3) (force-intercept,F0; velocity-intercept,V0; maximal power, Pmax), physical function [Short Physical Performance Battery (SPPB)], frailty (Fried criteria) and muscle power (5-rep sit-to-stand (STS) test using validated equations(4) were assessed at baseline and after training.

**RESULTS:**

CT and TT showed changes in Pmax (+33.3±32.7 W; +33.9±44.5 W), STS power (+53.4±33.3 W; +49.1±26.5 W), relative STS power (+0.7±0.4 W/kg; +0.7±0.3 W/kg), gait speed (+0.20±0.7; +0.15±0.9 m/s), SPPB (+2.4±1.3; +3.0±1.1), Frailty Phenotype (-1.1±1.1; -1.6±1.4 points) and Frailty Trait Scale 5 (-3.8±3.4; -4.5±2.7 points) (all p<0.05).

Also, CT increased V0 (+0.07m/s±0.15; p<0.05) and 6 min walking test (+75.8±34.2 m; p<0.05), while TT increased F0 (+137.6±214.1 N; p<0.05) and handgrip strength (+1.8±2.3 N), with no interaction between groups.

**CONCLUSION:**

Power-based concurrent exercise program, using either a traditional or a cluster set configuration, is a safe and well-tolerated strategy to improve physical function, frailty and muscle power in older adults. Interestingly, the individual F-V relationship should be evaluated to tailor the training program based on individual deficits.

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**EFFICACY OF A CHAIR-BASED EXERCISE INTERVENTION TO IMPROVE THE PERFORMANCE OF ACTIVITIES OF DAILY LIVING FOR NURSING HOME RESIDENTS**

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**INTRODUCTION:**

Nursing home residents are characterized by multimorbidity with strongly limited abilities to perform activities of daily living (ADL) (1). The loss of strength has functional consequences with regard to the residents' ability to perform ADLs and is associated with a higher degree of dependency and a reduced health-related quality of life (1). It is clearly stated that without exercise physical performance decreases over time in nursing home residents which aggravates the ability to perform ADL (2). On the other hand, there is evidence that exercise is able to improve the ability to perform ADL (2). Little research has been conducted on the question whether the effects on ADL performance are also perceived by the nursing staff. The study investigated the efficacy of a chair-based exercise (CBE) intervention regarding residents' physical function to perform ADLs and the perceptions of nursing staff.

**METHODS:**

The longitudinal study included N=12 multimorbid residents (85±5.2 years; 9 women, 3 men). A 16-week multicomponent CBE intervention, containing strength, endurance, mobility, and balance, was applied in a nursing home twice a week. Hand grip strength (Jamar hand dynamometer), functional reach, Barthel Index, finger and hand dexterity (Perdue Pegboard), physical and mental health (SF-12), wellbeing (SWLS) and cognitive function (MoCA) were assessed in a baseline (t1) and a post testing (t2). Additionally, a modified questionnaire based on the ADL care model by Krohwinkel was used after the intervention to assess the perceptions of nursing staff regarding the residents' ADL performance. For statistical analysis a repeated measures ANOVA was performed in SPSS.

**RESULTS:**

Small improvements could be observed but no statistical changes in hand grip strength, finger and hand dexterity and physical functioning. Functional reach, mental health and wellbeing showed minor deteriorations while cognitive functions remained stable. The evaluation of N=80 questionnaires showed that the nursing staff rated the ADL performance as stable and unchanged compared to the ADL performance before the intervention.

**CONCLUSION:**

The results indicate that a CBE intervention is able to sustain ADL performance within nursing home residents. No deterioration can be considered as a success in this aged population usually subject to a natural decline in ADL performance (2). The nursing staffs perception of

the residents' performance coincides with the results of the measurements. These perceptions are a factor that has so far not been considered in research. It is recommended to include this factor in further research.

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### EFFECTS OF AN 8-WEEK RESISTANCE TRAINING PROGRAM ON PHYSICAL FUNCTION AND FRAILITY IN POST-CARDIAC SURGERY PATIENTS OVER 70 YEARS OLD.

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## INTRODUCTION:

In-hospital concurrent exercise programs are beneficial to improve frailty and enhance muscular and physical function in elder patients[1]. Since muscle power (MP) is more related to physical function than muscular strength[2] these programs should focus on developing MP. However, the efficacy of these type of exercise programs has not been demonstrated on post-cardiac surgery patients.

## OBJECTIVES:

To study the effects of an 8-week concurrent exercise program on force velocity relationship (F-V), functional performance (FP) and frailty in older post-cardiac patients. We also aimed to study the relationship between baseline values and changes in F-V, FP and frailty.

## METHODS:

Thirteen post-cardiac surgery patients >70 y.o. (age: 80.3±5.1; SPPB: 6.9±1.8; FTS5: 24.1±6.1) were recruited. F-V and its parameters (i.e. force-intercept (F0), velocity-intercept (V0) and maximal power (Pmax)) were determined with a linear position transducer. Moreover, MP was calculated from STSpower test[3], physical function was assessed with SPPB and handgrip strength (HS). Frailty status was obtained in accordance with Frailty Phenotype[4] and Frailty Trait Scale (FTS5)[5]. An 8-weeks in-hospital concurrent exercise program was undertaken twice per week (power-oriented resistance training and cardiovascular exercise on a treadmill).

## RESULTS:

Improvements ( $p<.05$ ) were found in F-V in F0 (19%; CI 3-35%), Pmax(37%; CI 5-69%), and a tendency of improvement in load at Pmax (32%; CI [-5]-69%;  $p=.083$ ); STS power (73%; CI 10-137%) and STS relative power (71%; CI 6-137%); 4-m gait speed (30%; CI 17-43%;  $p<.001$ ); HS (12%; CI 3-22%); FTS5 (-18%; CI [-24]-[-12%];  $p<.001$ ). Neither baseline values of F-V, nor basal STSpower correlated with changes in functional performance nor frailty. However, baseline V0 correlated with handgrip gains ( $r=.55$ ;  $p=.051$ ). Conversely, baseline FTS5 had a relationship tendency with F0 gains ( $r=-.48$ ;  $p=.097$ ) and basal SPPB with V0 gains ( $r=-.53$ ;  $p=.063$ ). Besides, changes in V0 and Pmax were correlated with shifts in 4-m gait speed and time ( $r=.68$  and  $r=.66$ , respectively;  $p<.05$ ). Finally, changes in V0 correlated with changes in FTS5 ( $r=-.61$ ;  $p<.05$ ).

## CONCLUSION:

The concurrent exercise program improved muscle power, functional performance and frailty in older post-cardiac surgery patients. Although changes in V0 may be related to basal SPPB, these changes in V0 may explain the magnitude of the improvements in frailty. Thus, the prescription of an individualized program should take in consideration the F-V profile.

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### FROM UNTRAINED 55+ TO A TRIATHLETE. A PILOT STUDY.

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## INTRODUCTION:

It is well documented that cardiorespiratory fitness will significantly improve with systematic endurance training in older individuals (1). However, limited knowledge exists regarding the effects of sports related activities in this age group. There seems to be an increased tendency today, also for older adults, to exercise and compete in sports specific activities including triathlon, cycling, and marathon (2). Thus, there's a need for better understanding the training response in older adults completing an extensive training period with subsequent competitive event.

The aim of the present study was therefore to determine the training response of 8-weeks triathlon training in a group of untrained older adults with the intention to participate in a triathlon competition after the intervention period.

## METHODS:

The inclusion criteria were;  $\geq 55$  years, inexperienced with systematic endurance- and triathlon training, healthy. Fourteen individuals were included. Median age (interquartile range, IQR) for males ( $n=10$ ) and females ( $n=4$ ) were 70.0 (65.0-75.5) and 57.5 (56.3-62.5) years, respectively.

The participants conducted three training sessions per week, one swimming, one cycling, and one running session (80% of HRmax, 60-min per session), during a period of 8-weeks. Individualized training and supervision with professional instructors were prioritized throughout the intervention. Additionally, the participants were offered two seminars in sports nutrition and psychology (focusing on motivation, mastering).

Both field- and laboratory-based tests were conducted pre- and postintervention and consisted of a 20-minute-all-out cycling trial (mean power), a timed 3 km-all-out running trial, a timed 200-meter swimming trial, and a submaximal incremental test on the treadmill. Wilcoxon test was used to assess differences between pre- and posttest.

## RESULTS:

In the cycling trial, mean power significantly increased by 9.3% following training [pre(IQR): 167.0 (144.5-176.0) to post(IQR): 176.0 (167.0-193.0) (W),  $P<0.005$ ]. In both the running- and the swimming trial, time significantly decreased (-7.0% [pre(IQR): 20.6 (19.1-21.9) to

post(IQR): 18.7 (17.9-21.0) (min),  $P < 0.002$ ] and -13.9% [pre(IQR): 6.5 (5.7-8.1) to post(IQR): 5.9 (5.3-6.6) (min),  $P < 0.002$ ], respectively). In the submaximal incremental test, the velocity at the second lactate threshold did not significantly change (4.6%) [pre(IQR): 8.0 (7.3-8.4) to post(IQR): 8.5 (7.3-9.2) (km/h),  $P < 0.071$ ].

**CONCLUSION:**

In a group of untrained older adults, 8-weeks of extensive triathlon training increased power output during a 20-min cycling trial, and decreased time used in a 3-km running- and 200-meter swimming trial. All participants, except one due to medical reason, completed the Sprint distance (i.e. 750-meter swimming, 20-km cycling, 5-km running) in a local triathlon competition.

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**CP-MH09 Cardiovascular health****UNDERLYING MECHANISM OF ORTHOSTATIC INTOLERANCE DUE TO ATHLETE'S HEART; AN APPROACH WITH THREE-DIMENSIONAL ECHOCARDIOGRAPHY**

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**INTRODUCTION:**

It has been shown that the orthostatic tolerance is attenuated in individuals with low and high physical fitness levels. It was reported that orthostatic intolerance with low physical fitness would be attributable to cardiac atrophy and hypovolemic condition (ref). Although orthostatic intolerance with high physical fitness may be related to athlete's heart, the physiological mechanisms are still unclear. Furthermore, it remains completely unclear how left ventricular function would change in response to very high orthostatic loads up to presyncope. The purpose of the present study was to clarify left ventricular functional responses to very high orthostatic stress until presyncope in non-athletes and endurance athletes.

**METHODS:**

Twelve male non-athletes (age;  $25 \pm 5$  years, height;  $169.7 \pm 6.0$  cm, weight;  $67.4 \pm 8.5$  kg, mean  $\pm$  SD) and 12 male endurance athletes ( $23 \pm 8$  years,  $172.5 \pm 4.5$  cm,  $58.1 \pm 5.2$  kg) underwent maximal exercise stress test on a bicycle ergometer to assess maximal oxygen consumption (VO<sub>2</sub>max). Furthermore, Each participant underwent three-dimensional echocardiography during graded lower body negative pressure (LBNP) up to presyncope. A cumulative stress index (CSI) was calculated by adding the product of negative pressure and duration at each level of LBNP and was used as a measure of orthostatic tolerance. We evaluated the changes of left ventricular function in response to incremental LBNP, and compared its differences between the two groups.

**RESULTS:**

VO<sub>2</sub>max was significantly lower in non-athletes than in athletes ( $36 \pm 8$  vs  $59 \pm 4$  ml·kg<sup>-1</sup>·min<sup>-1</sup>,  $p < 0.05$ ). CSI was significantly higher in non-athletes than in athletes ( $1467 \pm 596$  vs  $1010 \pm 472$  mmHg·min,  $p < 0.05$ ). In response to LBNP, left ventricular (LV) ejection fraction (EF) (Baseline:  $62 \pm 3$ , LBNP<sub>1/2</sub>max:  $55 \pm 5$ , LBNPpre-max:  $43 \pm 9$  %, mean  $\pm$  SD,  $p < 0.05$ , ANOVA), LV global longitudinal strain ( $-20.5 \pm 2.8$ ,  $-17.6 \pm 2.7$ ,  $-13.6 \pm 4.7$  %,  $p < 0.05$ ), and LV global circumferential strain ( $-31.2 \pm 3.7$ ,  $-26.8 \pm 3.3$ ,  $-19.4 \pm 5.3$  %,  $p < 0.05$ ) were decreased in the non-athletes. LV twist ( $15.2 \pm 5.1$ ,  $14.5 \pm 5.4$ ,  $20.9 \pm 7.7$  °,  $p < 0.05$ ) and LV peak untwisting rate ( $-138 \pm 42$ ,  $-164 \pm 50$ ,  $-245 \pm 88$  °/cm,  $p < 0.05$ ) were increased at the LBNPpre-max. The LV peak untwisting rate was larger in the non-athletes at the LBNP pre-max as compared with the athletes ( $p < 0.05$ ).

**CONCLUSION:**

In non-athletes, LV myocardial strain and LVEF weakened, but LV twist and untwist strengthened in response to orthostasis. This response may be a compensatory mechanism for maintaining stroke volume. On the other hand, the endurance athletes didn't show augmentation of LV untwist during LBNP. Our findings suggest that the impaired left ventricular torsion against the orthostatic stress is possible underlying mechanism of orthostatic intolerance in the endurance athletes.

**THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVEL AND ARTERIAL STIFFNESS IN HEALTHY YOUNG ADULTS**

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**INTRODUCTION:**

Cardiovascular disease is the main cause of death in developed countries. Arterial stiffness is a well-known, independent risk factor for cardiovascular diseases. Even in healthy young adults, stiffened arteries can augment cardiovascular disease risk in the future. Previous findings have demonstrated that moderate to vigorous-intensity physical activity is a very effective behavioral intervention to improve cardiovascular function in middle-aged and older adults with or without chronic diseases. However, the related research studies for healthy young adult have scarcely been performed. The purpose of this study was to investigate the relationship between physical activity level and arterial stiffness in healthy young adults without overt clinical diseases.

**METHODS:**

Sixty healthy young adults participated in this study ( $24.2 \pm 0.4$  yrs). We measured the physical activity level for 7 consecutive days by using the wGT3X-BT accelerometers. To assess central artery stiffness, both aortic pulse wave velocity (AorPWV) and augmentation index (Aix) were measured by SphygmoCor Xcel system.

**RESULTS:**

Regarding total physical activity quantity (counts/min), young adults in the second highest quartile presented lower aortic pulse wave velocity compared with those in the third highest quartile (5.8 vs. 6.5 m/s,  $P = 0.03$ ). Total physical activity quantity was negatively related to augmentation index adjusted for the heart rate at 75 beats per minute ( $r = -0.24$ ,  $P = 0.03$ ). Physical activity time (min/day) with both vigorous and moderate to vigorous intensity was also negatively associated with the augmentation index adjusted for the heart rate at 75 beats per minute ( $r = -0.22$ ,  $P = 0.049$ ).

**CONCLUSION:**

In conclusion, an increase in total physical activity quantity and the physical activity time in the intensity higher than the moderate decreases arterial stiffness in healthy young adults, which may help to reduce the future cardiovascular disease risk.

## RELATIONSHIP BETWEEN CAROTID INTIMA-MEDIA THICKNESS AND INTRAMUSCULAR ADIPOSE TISSUE CONTENT IN MIDDLE-AGED AND OLDER NON-OBESE MEN

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### INTRODUCTION:

Intima-media thickness (IMT), a measure of early atherosclerosis, is a predictive marker for cardiovascular disease. IMT increases with aging in non-obese adults. Previous studies have also reported that carotid IMT in overweight and obese younger adults is associated with adipose tissue infiltration of muscle tissue (intramuscular adipose tissue) in the thigh, independent of insulin resistance and visceral abdominal adipose tissue. Based on these findings, carotid IMT may be associated with intramuscular adipose tissue content independent of age and body composition. Thus, the aim of this study was to investigate whether carotid IMT is related to the intramuscular adipose tissue content of the thigh in middle-aged and older non-obese men.

### METHODS:

Thirteen middle-aged (age 55.2±6.1 years, body mass index 22.1±2.0 kg/m<sup>2</sup>) and 31 older non-obese men (age 73.6±5.9 years, body mass index 22.6±1.8 kg/m<sup>2</sup>) participated in this study. The mean carotid IMT was measured by B-mode ultrasound imaging. Axial images of the mid-thigh were taken using magnetic resonance imaging and muscle cross-sectional area (CSA), and the intramuscular adipose tissue content of the quadriceps (QF) and hamstrings (HM) were assessed. Body fat percentage was measured using bioelectrical impedance analysis.

### RESULTS:

Carotid IMT and body fat percentage were significantly higher in older men compared with middle-aged men. Muscle CSA normalized by body weight (muscle CSA/body weight) in the QF and HM was significantly lower in older men than in middle-aged men. There was no difference in intramuscular adipose tissue contents of the QF and HM between middle-aged and older men. Carotid IMT was significantly correlated with intramuscular adipose tissue content ( $r=0.623$ ,  $p=0.023$ ) of the HM in middle-aged men, but not in older men ( $r=0.037$ ,  $p=0.844$ ). On the other hand, there was no significant correlation of carotid IMT with body fat percentage in middle-aged men ( $r=0.265$ ,  $p=0.381$ ) or older men ( $r=-0.154$ ,  $p=0.408$ ). No significant correlation was found between the Carotid IMT and muscle CSA/body weight of the QF and HM in middle-aged men ( $r=-0.243$ ,  $p=0.424$  and  $r=-0.417$ ,  $p=0.156$ ) or older men ( $r=-0.317$ ,  $p=0.082$  and  $r=-0.146$ ,  $p=0.433$ ).

### CONCLUSION:

These findings suggest that carotid IMT is associated with intramuscular adipose tissue content of the thigh in middle-aged non-obese men. In early morphological changes of the carotid arteries, the distribution of adipose tissue may be more important than the body fat percentage.

## METHODOLOGY AND FIRST RESULTS OF A NATIONWIDE DATABASE ON SUDDEN CARDIAC EVENTS IN SPORTS PRACTICE IN LUXEMBOURG

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### INTRODUCTION:

Sports practice is like the Roman God Janus: it has two faces. On one hand, regular physical activity reduces cardiovascular risk factors and improves life expectancy. But on the other hand, the risk of serious heart problems is increased during and immediately after exercise [1,2]. Sports-related sudden cardiac death in the general population is more frequent than suspected [3,4]. However, it often occurs in a predictable setting, allowing prompt interventions and improved survival rates.

The aim of this project was to create a national database to determine sports-related sudden cardiac event (SCE) burden in Luxembourg.

### METHODS:

To identify cases of SCE, a systematic data collection was carried out from 2015 until 2019 and relying on online questionnaires, public media (written, televised and electronic press) or direct witnesses.

All registered cases of SCE met the following criteria: (1) any major cardiac adverse event (sudden cardiac death or arrest), (2) event having taken place during or <1 hour after a sports activity (3) on national territory or outside Luxembourg by a Luxembourgish resident or sports license holder.

Wherever possible, the victim or the victim's family were contacted to inquire on the circumstances of the SCE by means of a standardized questionnaire. The results were introduced anonymously in the national database.

### RESULTS:

In total, 43 SCE cases were recognized over the 5 years. The incidence, estimated on the basis of 56% of the population being physically active in Luxembourg, is 2.6 cases/year/100000 inhabitants.

The 43 events occurred in 41 persons (40 males), at an average age of 49.7 years. Seventeen events were fatal, 20 cases occurred in public spaces, 19 in a gym and 4 at home. The most concerned sport activities were cycling (17 cases), followed by football (5) and running (4).

Of those, 24 victims suffered a sudden cardiac arrest, of which 16 received cardiopulmonary resuscitation by bystanders. Seven (29%) of those survived the arrest.

### CONCLUSION:

The present database serves to collect data on sports related sudden cardiac events in Luxembourg. The data collection of the last five years has shown that the number of cases is higher than reported in other international studies [3,4]. The heterogeneity of definitions of SCE and the population variety in the literature implies a careful analysis when interpreting the results.

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**ACUTE EFFECTS OF MULTICOMPONENT EXERCISE SESSIONS WITH DIFFERENT DURATIONS ON MARKERS OF ENDOTHELIAL REPAIR POTENTIAL AND VASCULAR HEALTH**

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**INTRODUCTION:**

Exercise is considered a key tool in prevention/treatment of cardiovascular diseases<sup>1</sup>, and the magnitude of benefits seems to have a dose-response relationship. However, little is known about the acute effects of multicomponent exercise sessions with different durations on markers of acute effects of multicomponent exercise sessions with different durations on endothelial repair potential and vascular health in adults endothelial progenitor cells (EPCs), hematopoietic stem cells (HSCs) and circulating endothelial cells (CECs). Therefore, the aim of this study was to compare two exercise sessions with different durations, in adults with cardiovascular risk factors.

**METHODS:**

Fifteen adults were enrolled in the study, and clinical data, anthropometrics and cardiorespiratory fitness were assessed at baseline. Two exercise sessions [Warm up, multicomponent interval training (brisk walking and calisthenic strength exercises) and cool down] were performed 1 week apart lasting 30 and 45min, respectively. The exercise intensity was controlled by Polar RS300x. Blood collection was performed before and immediately after the exercise. The EPCs (CD45dim/CD309+/CD34+), HSCs (CD34+) and CECs (CD45-/CD146+) were quantified by flow cytometry and reported as percentage of cells between the leukocytes.

**RESULTS:**

The participants were 64.6±8.6 years old (body weight 66.3 ±11.5kg; height 157.6 ±7.9cm, BMI 26.8 ±3.8kg/m<sup>2</sup> and VO<sub>2</sub>peak of 29.0 ±5.5 ml/kg/min). Regarding the effects of pre and post exercise, no significant changes were found in 30 and 45min exercise sessions in circulating EPCs (0.0097980 ±0.0023646 to 0.0109153 ±0.0027260, p=0.21 Vs. 0.0089300 ±0.0023844 to 0.0074360 ±0.0028287, p=0.53) and in CECs (0.0059340 ±0.0017603 to 0.0051480 ±0.0018596, p=0.24 Vs. 0.0065826 ±0.0019769 to 0.0070440 ±0.0017648, p=0.52, respectively). However, compared to 30min session, after the exercise session lasting 45min the circulating number of HSCs increased significantly (0.0153546 ±0.0044014 to 0.0183466 ±0.0074850, p=0.17 Vs. 0.0106826 ±0.0037802 to 0.0143173 ±0.0044296, p=0.001, respectively).

**CONCLUSION:**

A 45-minute multicomponent exercise session may enhance the circulating number of HSCs, which have shown beneficial vascular properties. Although 30 and 45-minute exercise sessions have not changed the number of EPCs, it seems not increase the endothelial damage (assessed by circulating CECs).

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**ANALYSIS OF PHYSICAL ACTIVITY PATTERNS IN RELATIVELY YOUNG SWEDISH HEART FAILURE PATIENTS**

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**INTRODUCTION:**

Positive effects of physical activity/exercise training (PA) in patients with chronic heart failure (HF) have been widely investigated (1) and showed negative correlations with HF-specific hospitalization rates and improved health-related quality of life (2). Although evidence is adjective that PA is beneficial and recommended for HF patients, there is a lack of studies analysing I) daily PA patterns more in detail (duration [min/%]; intensities; frequency) in different patient subgroups and II) the fulfilment of PA recommendations. More detailed PA studies are needed in the younger heart failure cohort. The aim of the study was to compare the detailed PA patterns and the fulfilment of PA recommendations in a Swedish chronic HF patients overall and in different specified subgroups.

**METHODS:**

38 female and 94 male patients with HF (age 34-74 yrs) participated in the study. Daily movement patterns were measured (50 Hz) by lightweight accelerometers (Axivity Ltd., Newcastle upon Tyne, UK) fixed in elastic belts around the patients' hips (7 days consecutively; without water activities). Raw accelerometer data was processed to tri-axial ActiGraph counts (epoch length of 60 s). Mean daily PA at low- (LIPA) and moderate- to vigorous (MVPA) intensity was calculated as well as fulfilment of PA recommendations by different definitions. PA volume and fulfilment of recommendations were analysed in five subgroups: Sex (male vs female); Age (34-58 vs. 59-74 yrs); EF (ejection fraction, <40 vs. ≥40%); Post-AMI (acute myocardial infarction, yes vs. no); NT-proBNP (N-terminal pro-Brain Natriuretic Peptide, ≤400 vs. >400 ng/L). Descriptive data is presented as median with 25th – 75th percentile (Q1-Q3) and as proportions. Mann-Whitney U (PA volume in subgroups) and Chi-square (fulfilment of PA recommendations in subgroups) tests were used (P<0.05).

**RESULTS:**

All patients spent 24.9% per day in LIPA and 2.7% in MVPA (p<0.05), with no sex differences. Younger patients and patients with an EF≥40% showed a tendency (p=0.08) of more PA (+1.4%/20min LIPA; +0.3%/8min MVPA). Post-AMI patients and patients with NT-proBNP >400 spent less time (p<0.05; -14 min (-1%) and -18 min (-1.2%)) in MVPA than their counterparts. 44.7% fulfilled the PA recommendations of 30 min MVPA on most days of the week.

**CONCLUSION:**

Only 2.7% of daily PA was spent in moderate intensity in a relatively young cohort of HF patients. Post-AMI and high NT-proBNP patients showed even less PA. Additionally, less than half of the patients fulfilled the general PA recommendations. Found differences between diverse subgroups show the relevance of evaluating the daily PA patterns in HF patients in detail. Further development of the analysis methods and the development of measures to increase PA in these patient groups are needed.

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**VASCULAR REMODELING IN PERI-PUBERTAL COMPETITIVE ENDURANCE ATHLETES**

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**INTRODUCTION:**

Sudden cardiac death is still a big issue in professional sports. Decades have been invested in research into the athlete's heart. In contrast, vascular remodeling is much less studied, however vascular diseases belong to the main causes of sudden cardiac death. Aortic root dilatation has been described in adult athletes as a consequence of intensive training [1]. The aim of this study was to investigate whether this vascular remodeling can already be found in young athletes, and if it is related to increased vascular stiffness.

**METHODS:**

Aortic root diameter and central PWV were assessed in 310 competitive endurance athletes aged 14,6±2,2 years (range 8-18 years) using transthoracic echocardiography and the oscillometric Mobil-O-Graph. The results of the measurements were compared to the pediatric reference values of two comprehensive studies [2;3]. Spiroergometry was performed to determine VO<sub>2</sub>max and maximal work load (W<sub>max</sub>). Additionally, regression analysis was performed on aortic root diameter and the PWV. This should confirm the prior findings. Finally, the prevalence of aortic root dilatation was evaluated applying the diagnosis criteria of the AHA/ACC [4].

**RESULTS:**

The aortic root diameter significantly differed between competitive athletes and the study population of Kampmann et al. by a mean of 0,9mm (p=0,029). The prevalence of the aortic dilatation was 6,5%. Aortic root diameter was associated with W<sub>max</sub> even after correction for BSA (r=0,180; p=0,002), but not with VO<sub>2</sub>max (r=0,074; p=0,195). Excluding obese or hypertensive subjects, no significant difference in central PWV to normal was found. PWV was not associated with W<sub>max</sub> or VO<sub>2</sub>max after correction for BSA.

**CONCLUSION:**

Aortic root diameter can also be increased in adolescents with competitive endurance training. Although the difference to normal is smaller compared with published values for older athletes, 6,5% of the young athletes of our cohort showed an aortic dilatation. Changes in central PWV as a possible functional explanation of arterial dilatation could not be demonstrated. Further studies are needed to gain more insight into the longterm vascular remodeling and its consequences.

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**CP-MH10 Injury prevention****CRICKET INJURIES IN NEW ZEALAND: A REVIEW OF TWELVE YEARS OF ACCIDENT COMPENSATION CORPORATION INJURY ENTITLEMENT CLAIMS**

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UNIVERSITY OF CANTERBURY

**INTRODUCTION:**

Cricket is a summer sport enjoyed by millions globally with high public participation rates. Given the huge popularity of cricket, it is somewhat surprising that most injury surveillance reports have only focused on elite cohorts. To improve the understanding of cricket injury aetiology and to quantify nationwide cricket injury prevalence, studying cricket-related injuries amongst the general public is essential. This study aimed to address research gaps in injury surveillance in the general sporting population by quantifying cricket-related injuries in the New Zealand (NZ) population from 2005 to 2016.

**METHODS:**

Cricket-related injury claim data were obtained from the NZ Accident Compensation Corporation (ACC) and categorised by age group, affected body areas, injury type and diagnosis. Using the NZ population censuses, the age-standardised injury incidence (ASII) per 10,000 people-years was calculated using the Segi world standard for each calendar year. Each categorised grouping was then divided by summed total injuries and presented as a percentage.

**RESULTS:**

A total of 77212 injuries were recorded, and the ASII increased by 42% over the 12 years (2771 in 2005 to 3936 in 2016 - per 10,000 people-years). Notably, age groups 10-14 (16.8%) and 15-19 years (17.5%) had the highest injury prevalence. Soft tissue injuries (76%) were the most prevalent injury type, with 69% of all injuries due to contact, leaving the remainder from a non-contact cause, mainly due to repetitive strenuous movement. The back/spine (31.4%) and shoulder (20.2%) areas experienced the highest non-contact injury prevalence. Of note, the shoulder (84.6%) and back/spine (75.7%) also displayed the highest increase in injury prevalence compared to all other body areas over the 12 years.

**CONCLUSION:**

Non-contact soft tissue injuries to the shoulder and spine are a contemporary concern as these body areas have experienced the highest increase in injury prevalence. We recommend that injury prevention programmes should target these injury-prone body areas.

**INJURIES IN THE LOWER EXTREMITY AND RELATED FACTORS IN CANYON-TYPED MARATHON RUNNERS: THE FINDINGS OF SELF-REPORTED QUESTIONNAIRES 2013 – 2018**

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**INTRODUCTION:**

There is an increased popularity in marathon-running all over the world, because of its positive influence on personal health and physical fitness (1, 2). Nevertheless, running-related injuries (RRIs) is mainly occurred in the lower extremity in this population (3). Due to the inconsistent findings from previous literature for RRIs in the lower limb, we aimed to 1) examine the injuries and related factors in the canyon-typed recreational marathon runners retrospectively from the questionnaire from 2013 to 2018, and 2) assess the immediate effects of sports physiotherapy interventions on those self-reported injured runners.

### METHODS:

A modified self-reported running injury questionnaire was used in a canyon-typed marathon game (approximately 6000-8000 marathon runners per year) since 2013. Runners were admitted to the sports physiotherapy station when the initial completion of questionnaires before the intervention of sports physiotherapy. A total of 718 questionnaires were received from 2013 to 2018, 709 questionnaires were fully completed for further statistical analysis. The descriptive statistics and Chi-Squared Test and Independent t-test were used to examine the characteristics in the anthropometry and injury data of the runners, respectively. Logistic regression analysis was used to determine the factors (age, gender, body mass index, education, types of marathon and previous injury) associated with the incident injury). The paired t-test was used to examine the immediate significant change in pain perception between pre- and post-intervention.

### RESULTS:

The major areas of injury reported before and after the marathon were the knee (38% vs. 28%), calf (32% vs. 20%), anterior thigh (20% vs. 13%), foot and ankle (20% vs. 10%), and plantar sole (16% vs. 8%). The risk factors were found significantly in gender (injury over the anterior thigh: male vs. female OR=2.42,  $p=0.002$ ) and BMI (underweight, injury over the anterior thigh: OR=3.35,  $p=0.006$ ). Runners with underweight appeared lower knee injury (OR=0.32,  $p=0.017$ ). More interestingly, all visual analog pain scales were reduced significantly after the interventions (difference  $3.61\pm 1.74$ cm,  $p<0.001$ ).

### CONCLUSION:

Significant injuries in the calf, anterior thigh, and plantar sole were found in the canyon-typed marathon. Sufficient sports physiotherapy may dramatically reduce pain and symptom immediately after running in a marathon.

## ULTRASONOGRAPHIC TISSUE CHARACTERIZATION OF ACHILLES TENDON STRUCTURE, JUMPING AND BALANCE PERFORMANCE IN ROAD AND TRAIL LONG DISTANCE RUNNERS

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### INTRODUCTION:

Training surfaces influence load absorption, ground reaction forces and the kinematics of the lower extremity. As training surfaces change the load and joint kinematics, running regularly on different surfaces might affect the load on the Achilles tendon and its adaptive changes. In addition, the different load might also influence the athletes lower extremity function, balance, strength and proprioception.

The aim of the study was to investigate Achilles tendon structure and functional tests in road and trail runners.

### METHODS:

The study included 26 road and 17 trail runners. All running at least 3 times per week with a minimum of 20km per week and had participated in running competitions over 2 years. Each participant was examined for Achilles tendon structure via ultrasound tissue characterization (UTC) imaging. UTC renders a three-dimensional image from transverse images and the stability of pixel brightness is calculated and categorized into four echo types correlating to the degree of structural homogeneity. The percentages of Echo types I, II, III and IV within the tendon, tendon length and width and tendon cross sectional area were measured. In addition, the following tests were performed: Ankle inversion movement discrimination ability was measured via Active Movement Extent Discrimination Apparatus (AMEDA) device; dynamic postural balance via Y balance test; jumping performance by triple hop distance test and hip muscle abduction muscle strength by hand held dynamometry.

### RESULTS:

Significant difference in the distributions of the four echo-types in the UTC examination was found between groups. Percentage of echo-types I was significantly lower while echo-types II was higher in the road group compared with trail group (67.3%, 28.9% and 74.15%, 22.1%, respectively) ( $p<0.001$ ). No significant differences between groups was found for other tests.

### CONCLUSION:

Tendon integrity as examined with UTC is different between road and trail runners. These finding suggest an influence of running surface on Achilles tendon structure. This difference was not reflected in other performance tests thus the influence of tendon structure on function needs further examination.

## DRUG / SUPPLEMENT USE AND CONFIRMING BEHAVIOR OF PROHIBITED SUBSTANCES IN JAPANESE UNIVERSITY ATHLETES AND ORDINARY STUDENTS

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### INTRODUCTION:

Japanese university athletes have low anti-doping (AD) knowledge. Their lack of responsibility for what they ingest, and insufficient side effect awareness is evident 1. When athletes use drugs, the confirming behavior (CB) of the prohibited substance is insufficient 1. Unlike drugs, the actual condition of CB for supplements with unclear ingredients is not clarified. Under the International Standard for Education to be formulated in the 2021 Code, university students will also be subjected. Therefore, AD education based on public health is also needed. To implement relevant education, understanding drug and supplement use and CB among university students is imperative. This study aims to reveal the current situation among students and to explore the directions for AD education.

### METHODS:

We collected data from 388 male and 391 female university students. We asked about their drug and supplement usage over the last year, and assessed supplement CB with the question: "Have you confirmed whether the supplement you use contains banned substances specified in the anti-doping prohibition list?" Response options were: 1, no; 2, not really; 3, somewhat; and 4, yes. We compared scores between individual attributes (ordinary student, district, prefectural, national, and international level) using the  $\chi^2$  test.

### RESULTS:

Annual university student drug use was 71.8%, ordinary students 76.7%, national 74.6% and international 90.5%. Annual supplement use by university students was 61.0%, ordinary students 73.6%, national 53.6% and international level 76.2%. The supplement's average CB

was 1.44 points ( $\pm 0.87$ ). Comparing attributes, there was a significant difference and the effect size was average ( $p < .001$ ,  $V = 0.327$ ): national level was significantly higher (response 4), but ordinary students were lower ( $p < .01$ ). International level remained 3, somewhat ( $p < .01$ ). Average CB for ordinary students was 1.04 ( $\pm 0.22$ ), national 2.20 ( $\pm 1.19$ ), and international level was 2.19 ( $\pm 1.17$ ).

#### CONCLUSION:

University student drug and supplement use shows that international-level medicine use is higher than other groups. And while ordinary student drug use is lower than the national level, a high proportion use supplement. For CB supplements, the international level was response 3 and CB was insufficient. The "yes" ratio was significantly higher at the national level. But average values at national and international levels for CB indicated response 2. Previous studies found inadequate drug and supplement CB in top athletes. These findings suggest AD education should target both athletes and ordinary students with less awareness of CBs in terms of "athletes responsibilities," and public health.

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## CP-MH11 Women and sport

### COVID-19 PANDEMIC CONFINEMENT AND LINKS BETWEEN PHYSICAL ACTIVITY AND PELVIC FLOOR DISORDERS IN PREGNANT WOMEN

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#### INTRODUCTION:

During pregnancy, the growing foetus and hormonal changes elicit abdominal hyperpressure. In turn, this induces specific body adaptations at the pelvic floor (PF) level that can lead to physical and mental disorders such as low back pain (LBP), incontinence, anxiety... To limit these troubles, pregnant women (PW) are encouraged to practice 150 minutes of aerobic activity per week [1] and to improve control (contraction and relaxation) of PF muscles with specific reinforcement training [2]. During COVID-19 pandemic, most of governments advocated confinement of population in order to reduce the virus spread, which led to a sedentary lifestyle in PW [3]. This study aimed to explore the consequences of COVID-19 pandemic confinement on the link between Physical Activity (PA) and PF disorders in PW.

#### METHODS:

A survey including the Spielberger questionnaire for anxiety assessment, the SF-36 questionnaire for quality of life (QoL), the French PA questionnaire for PW (PPAQ) and the Pelvic Girdle Questionnaire [4] was web-distributed to 91 PW from three countries: Belgium ( $n=29$ ), Canada ( $n=33$ ) and France ( $n=29$ ), between 03/20/2020 and 03/26/2020. Differences between nationalities were explored using a unidirectional ANOVA. Correlations between the variables of the different questionnaires were carried out using a PEARSON analysis. Any difference or correlation is significant when  $p < 0.05$ .

#### RESULTS:

During Covid-19 pandemic, PA was below recommendations in all PW. Significant correlations were found between weeks of amenorrhea and LBP, and between LBP and SF-36 physical health in Belgian PW ( $p=0.022$  and  $0.041$ , respectively) and Canadian PW ( $p=0.001$  and  $0.033$ , respectively), not French PW. For Belgian PW, the more pregnancy is advanced, the more mental health perceived is good ( $p=0.037$ ). In French PW, anxiety increases along weeks of amenorrhea ( $p=0.042$ ).

#### CONCLUSION:

PA decrease induced by confinement during COVID-19 pandemic might partly explain PF disorders and their consequences on QoL in PW. However, variations in QoL observed between nationalities remain unclear and need to be explored to improve adapted protocols during pregnancy.

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### A FIELD STUDY INVESTIGATING THE EFFECTS OF A NOVEL PADDING DESIGN IN WOMEN'S CYCLING SHORTS

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#### INTRODUCTION:

Genital discomfort is often reported by female cyclists (1) and can be decreased by means of ergonomics interventions (e.g. 2). According to our knowledge, no studies have investigated the effects of using ergonomically designed cycling shorts on genital discomfort among female cyclists. Our objective was to compare two types of cycling shorts padding across 3 months in field conditions. Outcome variables were perceived discomfort, wetness sensation, thermal sensation, and texture sensation.

#### METHODS:

One hundred and eighty-three female recreational cyclists (mean  $\pm$  SD age:  $45.0 \pm 12.1$  yr, height:  $169.1 \pm 6.1$  cm, body mass:  $67.0 \pm 9.7$  kg) volunteered to take part in the study. The participants were divided into two groups using k-means clustering algorithm: an intervention group (INT) that received cycling shorts with a novel type of padding exclusively located at the ischial tuberosities (half-pad) and a control group (CON) that received cycling shorts with a traditional type of padding located at both the ischial tuberosities and the crotch area (full-pad). Participants were instructed to use the cycling shorts for three months. An online questionnaire was developed to assess sensory changes in specific aspects associated with genital discomfort. Perceived discomfort (scale from 0 to 100), wetness sensation (0 to 30), thermal sensation (-10 to 20), texture sensation (-9 to 9), and wear discomfort (1 to 7) of the pad at the ischial tuberosities and crotch area were assessed before and three months after receiving the cycling shorts.



RESULTS:

One hundred and forty-nine participants responded to both pre- and post-questionnaires. A significant group  $\times$  time interaction ( $F_{1,147} = 7.8, P = 0.006$ ) indicated that the perceived discomfort at the ischial tuberosities was reduced in INT (mean change  $-11.1, 95\% \text{ CI}, -15.3$  to  $-6.9, P < 0.001$ ) after three months, while no change was observed in CON (mean change  $-2.7, 95\% \text{ CI}, -6.9$  to  $1.5, P = 0.212$ ). A similar trend ( $F_{1,147} = 3.0, P = 0.087$ ) was found for the perceived discomfort in the crotch area. Main effects of time were found for all other outcomes (all  $P < 0.05$ ), except for the wear discomfort of the pad on the crotch ( $P = 0.108$ ). These effects indicated decreased wetness sensation and thermal sensation, and increased texture sensation after three months, regardless of the type of cycling shorts.

CONCLUSION:

Female cyclists who used cycling shorts with a novel half-pad design for three months reported reduced perceived discomfort at the ischial tuberosities at the end of the study period. The current analysis showed that a field-based study combined with an online questionnaire enables the evaluation of newly designed products such as cycling shorts padding for females in field conditions.

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**BICYCLE'S SADDLE IN ELITE FEMALE ROAD CYCLISTS: GEOMETRY PREFERENCES AND COMFORT**

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UNIVERSITY OF LEÓN

INTRODUCTION:

Having a correct bike fit while cycling is one of the main factors affecting performance, comfort and efficiency, as well as injury prevalence [1]. Nowadays, a large number of competitive cyclists experience some discomfort due to their bike-fit or saddle type, which also has some effect on the degree and location of such discomfort. However, there is still an open field on this topic in relation to women, as the number of studies on this matter is quite limited [2]. Therefore, the main purpose of the present study is to analyze the saddle' geometry preferences and comfort level on women's elite cycling.

METHODS:

Sixty women elite cyclists participated, whom took part in the National women's road cycling Cup on the 2018-19 season (43% of the whole population). Firstly, an 18 items comfort questionnaire was made (it included both saddle use background and saddle comfort items) and after completed by the cyclists. Secondly, saddle dimensions (length, maximum width, and the distance from that point to the end of the saddle) were collected by attending one training camp and three different races. Lastly, the previously collected data were statistically analyzed.

RESULTS:

The main outcomes indicate that half of the cyclists had discomfort caused by the saddle (wounds, chaffing or pain). In general, the riders preferred the women's specific saddle over the men's one (50 vs. 39%). Furthermore, men's saddle caused more discomfort than women's saddle (60 vs. 39%). It was also found a connection between the type of saddle and the area of the saddle where the riders were sitting (i.e.; closer to the back on the men's saddle), which is related to the zones of discomfort (i.e.; more discomfort on the crotch when using the men's saddle and more discomfort on the ischial tuberosity when using the women's one). Quantitative analysis showed that women's saddle were wider, had a greater relationship between width and length, and had a shorter distance from the wider part to the end of the saddle than men's saddle.

CONCLUSION:

Women elite cyclists experience higher discomfort levels caused by the saddle than men referred in previous studies (50 vs. 7-31%). There was clear evidence that women's saddles help reduce discomfort levels when compared to men's saddles, even though the shape and geometry of the current saddles used by female cyclists in competition should be improved. Saddle type may also have some effect on bike-fit (i.e.; saddle back); therefore, future studies on women's cycling are needed to further explore this association.

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**FATIGUE INCREASE INTER-LIMB ASYMMETRIES IN FEMALE ADOLESCENT TEAM-SPORT ATHLETES.**

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CONSELL CATALÀ DE LESPORT

INTRODUCTION:

Between-limb asymmetries' interest has substantially increased during recent years in the context of sports injury prevention and players performance.

Neuromuscular asymmetries have been described as one of the main modifiable risk factors of suffering injuries such as Anterior Cruciate Ligament tear (1). In high performance athletes, asymmetries greater than 10% between the muscle groups of both limbs multiply by 4 the risk of injury (2).

The manual dynamometer has proven to be valid and reliable for measuring isometric force (3).

The main goal of this investigation was to study how the neuromuscular fatigue affects to the neuromuscular asymmetries on the quadriceps and hamstrings of basketball and handball teenager female players.

METHODS:

This is an experimental, pre-post intervention study with a sample of 29 high-performance female athletes, 19 basketball players and 10 handball players ( $17.2 \pm 1.19$  yo  $177.8 \pm 7.2$  cm and  $68.6 \pm 9.3$  kg). To record the muscle strength the athletes had to do a maximum isometric strength test (manual dynamometer, MARK 10 Corporation, NY), performed in a  $90^\circ$  hip and  $60^\circ$  knee position. Then the force asymmetries between the quadriceps of both limbs were calculated and the same process with the hamstrings. Regarding the intervention of the study, it was done by the intermittent fatigue test 30-15 (30-15 IFT).

To identify functional imbalances between limbs, we calculated the ASI using the following formula (Fort, 2015). The more skilful leg was determined to be the leg with higher performance averages on each respective task (4).

% ASI = ((Skilful – Non-Skilful)/Skilful) \*100

A descriptive analysis and a T-test were performed to study the differences in pre-post intervention asymmetry.

RESULTS:

After 30-15IFT, the asymmetry of muscular strength between the quadriceps and the hamstrings increases statistically significantly. In the quadriceps, the asymmetry goes from 6,44% before the fatigue test to 9,87% after 30-15IFT ( $p \leq 0.02$ ) and in the hamstrings from 6,50% before 30-15IFT to 9.30% ( $p \leq 0.03$ ).

CONCLUSION:

The conclusions of the study denote that after a fatigue test, the muscle strength asymmetry of quadriceps and hamstrings increases in this youth female players.

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### ASSOCIATIONS BETWEEN HIGH INTENSITY ACTIONS IN MATCH PLAY AND SPRINT, JUMP AND STRENGTH TESTS IN FEMALE FOOTBALL PLAYERS: A PILOT STUDY

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INTRODUCTION:

The importance of High intensity activities in football is increasing. However, studies reporting associations between laboratory tests and physical performance in match settings are scarce. By using tracking systems, only weak to no correlations is found for laboratory tests such as counter movement jump (CMJ) and 10 m sprint, when compared to and high intensity match activities. Further, these findings are limited to male football players. To our knowledge, there are no studies assessing the association between laboratory tests and high intensity actions in matches in female football players.

METHODS:

We recruited 22 outfield female football players from two football teams (level 2 and 3 in Norway) to play two pre-season matches using a stationary radio-based tracking system (SRBTS) (ZXY Sport Tracking System, Trondheim, Norway) and undergo two rounds of tests (1 repetition maximum (1RM) barbell half squats, CMJ, and 15m sprint with split times at 5-, 10-, and 15m), with 2 weeks between matches and tests. For 10 of the players, two matches and two rounds of tests were averaged for data points, while for 12 players, only one match and one round of testing were included for analyses. Match variables from the SRBTS included total distance (m), running distance (m), high intensity running distance (m), sprint distance (m), peak speed (m/s), accelerations (counts) and decelerations (counts). A correlation of 0-3, 0.3-0.7 and 0.7-1.0 indicates low, moderate and high correlations, respectively.

RESULTS:

Peak speed in match was negatively correlated with 10m ( $r=-0.71$ ) and 15m sprint time ( $r = - 0.68$ ) but positively correlated with jump height in CMJ ( $r = 0.61$ ,  $p < 0.01$ ). We observed a negative correlation between high intensity running distance in match and 15m sprint time ( $r = - 0.44$ ), and between sprint distance in match and 10m ( $r = - 0.57$ ) and 15m sprint time ( $r = - 0.56$ ). Acceleration counts in match was negatively correlated with 10 m ( $r = - 0.50$ ) and 15 m sprint time ( $r = - 0.53$ ). Total distance and deceleration counts in match were not correlated with any laboratory test.

CONCLUSION:

In our study, we observed a high correlation between 10 m sprint time and peak speed in match, while 15 m sprint time and CMJ was moderate correlated with peak speed in match. This indicate that sprint and jump height is associated, and 1RM squat strength is not associated, with high intensity actions in matches for females. However, due to our low sample size, some precaution should be made to our interpretation. Future similar research should include larger sample sizes, more matches, and position specific analyses to further elucidate the importance of high intensity actions in female football.

### CARDIAC VAGAL OUTFLOW SATURATION AND AEROBIC FITNESS CHANGES IN HIGH-LEVEL FEMALE SOCCER PLAYERS DURING THE PRESEASON

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INTRODUCTION:

Analysis of heart rate variability (HRV) from 24-h ambulatory recordings is a widely used noninvasive tool in the assessment of autonomic regulation in various physiological and clinical settings (1,2). HRV is expected to positively change in response to improved cardiorespiratory fitness in athletes. The purpose of this study was to investigate the changes in 24-hour HRV and aerobic fitness, and their associations, in female soccer players during the preseason period.

METHODS:

Sixteen players were assessed (24-hour HRV and Yo-Yo Intermittent Recovery Test, level 1 [YYIR1]) before and after 4 weeks of preseason. The relationship between R-R24h length and high-frequency oscillations (HF24h) was analysed by a quadratic regression model (revealing or not saturation of vagal activity) assessed 48-h before (PRE-preseason) and 48-h after (POST-preseason) the preseason period. Additionally, the mean HF24h was calculated from the linear portion of the R-R interval versus the HF24h regression curve (HF index). The average of the corresponding R-R24h values was defined as the R-R index.

RESULTS:

In the PRE-preseason, the relationship between R-R24h length and the corresponding HF24h was saturated in 7 players and linear in 9 players, while in the POST-preseason, 5 new cases of saturated HF24h were observed and remaining 4 players maintained linear relationship. Moderate effects with increased values were found for the mean R-R24h, HF24h, R-R index and HF index lengths, when compared the saturated with linear players for PRE and POST-preseason. Significant differences with large effects were found in YYIR1 PRE- compared to POST-preseason [ $930 \pm 286$  m (individual range: 400–1240 m) vs.  $1265 \pm 252$  m (640–1640 m), respectively;  $p < 0.001$ ]. Additionally, the

percentage changes of HF24h and HF index were largely correlated with improvements in the distance covered during the YYIR1 ( $r = 0.68$  and  $r = 0.56$ ; respectively).

**CONCLUSION:**

High-level female soccer players undertaking high training loads during a 4-week preseason period demonstrated increased aerobic fitness as assessed by a field-based intermittent running test, along with increased 24-h cardiac vagal activity. This enhanced vagal modulation led some players to transition from non-saturated to saturated vagal outflow throughout the day. Additionally, changes in 24-hour HRV were associated to changes in aerobic fitness, suggesting that monitoring cardiac autonomic can aid in the optimization of training responses. The procedures presented here can be easily assessed at the training facilities and/or the players' own homes, making implementation possible in a team's daily routine in a real-world scenario. Also, the wearable monitoring technology used in this study enables ambulatory cardiovascular monitoring on a scale not achievable with traditional techniques (e.g. Holter).

1. Huikuri HV et al, *J Am Coll Cardiol*, 34: 1878–1883 (1999).

2. Tulppo MP et al., *Am J Physiol Heart Circ Physiol* 274: H424-H429 (1998).

**EFFECT OF HOME BASED RESISTANCE EXERCISE ON BONE MINERAL DENSITY AT FEMORAL NECK IN YOUNG WOMEN**

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**INTRODUCTION:**

Dynamic loading is more effective for strengthening bone than static loading and the strain rate is more important than the loading magnitude (Lanyon and Rubin, 1984). Based on our previous study, 10 maximum vertical jumps/day, 3 days / week significantly enhanced bone mineral density (BMD) at the femoral neck in young women (Kato, 2006), our hypothesis of the present investigation was that home based low-repetition resistance training program of 10 leg-raise repetitions / day, 3 times / week would not be effective for improving BMD at femoral neck region in ordinary young women.

**METHODS:**

Eighteen female college students, with mean age, height and weight of  $20.6 \pm 0.6$  years,  $157.4 \pm 3.7$  cm and  $50.3 \pm 6.1$  kg, respectively, trained leg-raise exercise for 6 months. In the leg-raise training, the participants raised both legs as vertical as possible from the supine position with their knee flexed by about 90 degrees.

**RESULTS:**

After the leg-raise exercise intervention period, BMD measured by dual energy X-ray absorptiometry in the femoral neck region ( $0.991 \pm 0.094$  vs  $0.991 \pm 0.094$  mg/cm<sup>2</sup>), Ward's triangle ( $0.936 \pm 0.090$  vs  $0.995 \pm 0.087$  mg/cm<sup>2</sup>), greater trochanter ( $0.772 \pm 0.098$  vs  $0.767 \pm 0.094$  mg/cm<sup>2</sup>) and the total proximal femur ( $0.967 \pm 0.110$  vs  $0.971 \pm 0.107$  mg/cm<sup>2</sup>) showed no significant change from the baseline (% changes were 0.06%, 0.01%, -0.47%, 0.42%, respectively). On the other hand, the lumbar spine (L2 - L4) BMD significantly increased from the baseline ( $0.991 \pm 0.115$  vs  $1.015 \pm 0.113$  mg/cm<sup>2</sup>;  $p < 0.01$ ).

**CONCLUSION:**

Since an adaptive response occurs only when a loading stimulus exceeds the usual loading conditions, the present study required a load which did not exceed the usual daily life loading condition levels at the proximal femur. High-impact exercise such as jumps are suggested to be one of the ideal training methods for enhancing and maintaining peak bone mass in young women. Leg-raise exercise may potentially have the site-specific effect on lumbar spine in young women.

Kato T, Terashima T, Yamashita T, Yasuhiko H, Konda A and Umemura Y. Effect of low-repetition jump training on bone mineral density in young women. *J Appl Physiol*, 100:839-843, 2006

Lanyon LE, Rubin CT. Static vs dynamic loads as an influence on bone remodelling. *J Biomech* 17: 897-905, 1984.

Rubin CT, Lanyon LE. Regulation of bone mass by mechanical strain magnitude. *Calcif Tissue Int* 37:411-417, 1984.

**SIDE-TO-SIDE DIFFERENCES IN OSTEOGENIC RESPONSES OF THE PROXIMAL FEMUR AND CALCANEUS IN FEMALE FENCING PLAYERS**

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**INTRODUCTION:**

In fencing, the leg on the side that handles the sword is always the front leg (FL), therefore greater impacts are loaded on the LF compared to the back leg (BL). In fact, the thigh circumference, muscle volume, and muscle strength of the FL tend to be greater than the BL. These factors are deeply linked with osteogenic responses, such as bone mass and strength. Additionally, it is speculated that bone parameters of the calcaneus also differ between both legs, as well as the thigh. However, there are few studies which focus on osteogenic responses in fencing players. Here, the aim of this study is to investigate the side-to-side differences of bone parameters of the femur and calcaneus in female collage fencing players.

**METHODS:**

The subjects included 15 female college fencing players (age= $20.4 \pm 1.1$  year, athletic career= $7.5 \pm 3.2$  year, age at menarche= $12.1 \pm 1.0$  year). They all had eumenorrhea and no-history of fatigue fractures in the last year. The circumference of the thigh was measured 20 cm distally from the greater trochanter using a measuring tape. The bone mineral density (BMD) at the femoral neck (N), ward's triangle (W), trochanter (Tro), shaft (S), and total hip (T) were analysed by dual-energy X-ray absorptiometry (Lunar iDXA Prodigy). Bone stiffness (BS), broadband ultrasound attenuation (BUA), and speed of sound (SOS) at the calcaneus were measured by quantitative ultrasound (A-1000EXP II). Additionally, serum osteocalcin, bone specific alkali-phosphatase, and tartrate-resistant acid phosphatase 5b were measured after overnight fasting.

**RESULTS:**

All bone markers in individuals were within the normal range. The thigh circumference of the FL was significantly greater than that of the BL ( $p < 0.01$ ). The mean T-score of BMD was  $2.3 \pm 0.9$  and  $2.2 \pm 1.0$  in the FL, and  $1.8 \pm 0.9$  and  $1.3 \pm 0.8$  in the BL at N and T, respectively. Thus, fencing players have a high BMD of the proximal femur compared to the mean of young adults, in both legs. The BMD of all sites, with the exception of W in the FL, were significantly higher than those in the BL ( $p < 0.01$ ). The mean differences between legs were 5.3% at N, 9.5% at T, 2.2% at W, 12.1% at Tro, and 9.1% at S. On the other hand, there were no significant differences in BF, BUA, or SOS.

**CONCLUSION:**

Our data show a significant side-to-side difference in BMD of the proximal femur and non-significant differences of the calcaneus in fencing players. These results suggest that the impacts may differ among the thigh and foot, despite the side. Though the effects of sports on bones are site-specific, our results are somewhat unexpected. Further studies are needed to determine whether these differences are caused by individual movement-characteristics or other factors.

## CP-MH12 Ageing

### EFFECTS OF PHYSICAL EXERCISE ON PLASMA LEVELS OF BRAIN-DERIVED NEUROTROPHIC FACTOR IN NEURODEGENERATIVE DISORDERS: A META-ANALYSIS

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#### INTRODUCTION:

Age-related structural brain and cognitive changes are inevitable. However, physical activity is considered as one of the keystones to prevent, delay, or even reverse the neurodegenerative process. Brain derived neurotrophic factor (BDNF) is an essential protein with several functions in neural and non-neural tissues, mediating the development, survival and maintenance of peripheral and central nervous system (1). Among other treatments, physical exercise is believed to promote positive regulation of this neurotrophin (2). As BDNF levels has shown to be reduced in people with neurodegenerative disorders, physical exercise could be a particularly effective therapy in the delay of the neurodegenerative process in people with these conditions. This study aimed to analyse the impact of physical exercise on BDNF in people with neurodegenerative disorders.

#### METHODS:

A systematic search was performed in Pubmed, Scopus, Web of Science, PsycINFO and COCHRANE databases. The inclusion criteria were: i) Randomized controlled trials assessing the effects of physical exercise on BDNF levels in people with neurodegenerative disorders; and ii) peripheral measurement of BDNF before and after exercise intervention. The Cochrane Collaboration tool was used to assess the risk of bias. Pre- and post-intervention neurotrophin values were extracted and the standardized mean differences (Z) were estimated using a fixed-effect model in the absence of heterogeneity (<50%) or a random-effects model when heterogeneity was 50% or greater

#### RESULTS:

Of 4235 initial results, a total of 21 (with a total sample size of 814) were finally included in the systematic review and meta-analysis. The risk of bias in the included studies was overall high, showing deficiencies in the blinding domain mainly. Overall, BDNF concentrations in peripheral blood increased significantly after a physical exercise program for Multiple Sclerosis (Z=4.5, p<0.00001; 11 studies), Parkinsons disease (Z=2.71, p=0.007; 3 studies) and mild cognitive impairment (Z=2.15, p=0.03; 5 studies) but not for dementia (Z=0.83, p=0.41; 2 studies). There were no studies in other neurodegenerative disorders. When analysing the different types of exercise within these programs, the increase in the peripheral BDNF concentrations was significant following concurrent exercise (Z=4.48, p<0.00001), aerobic exercise (Z=2.87, p=0.004) and resistance exercise (Z=2.38, p=0.02).

#### CONCLUSION:

Physical exercise as an additional component of rehabilitation in people with neurodegenerative disorders increases BDNF levels, which can lead to slowing down the degenerative processes associated with these complex conditions.

### ADHERENCE TO ACTLIFE PROGRAM IN WOMEN WITH POST MENOPAUSAL OSTEOPOROSIS

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#### INTRODUCTION:

Osteoporosis is a systemic disease of the skeleton characterized by a reduced bone mass. This is accompanied by an increased risk of fracture with consequent pain, decreased physical and social functional capacity and quality of life. Many studies showed that an exercise program is important for maintaining or increasing bone mineral density in subjects with low bone mass. However, a low percentage of adherence to the programmes was found, about 50% leave before 6 months, lack of time being the number one barrier in many populations (1). The aim of this study was to evaluate the adherence of a ACTLIFE program when administered Individually as Home Training (IHT) or in Gyms as Group Training (GGT) in women with osteoporosis.

#### METHODS:

A cohort of 22 women (63 ± 5 years) were recruited by the Center and Metabolic Skeleton Diseases of the Rizzoli Orthopedics Institute (Bologna, Italy). Each participant was randomly assigned to IHT (n=11) or GGT (n=11) group. The GGT group was supervised by the trainers during training session, while the IHT group received educational material with the exercises explained, a logbook and a written exercise program. The exercise program was changed every 6 weeks and the subjects met the trainers to have the new program explained. They were also monitored with a call every 15 days to verify if there were any problems in performing the program. Each exercise session was divided in: warmup, balance, strength and cool down. Both groups did 22 weeks of training, twice a week, one hour per session. The total of the training sessions was 41 (100%). The adherence was registered with a logbook for the IHT group and with a register for the GGT group. After 6 months, the percentage of adherence was evaluated.

#### RESULTS:

The percentage of adherence reached 76% ± 17% in the GGT, while 81% ± 10% in IHT. No adverse events were observed.

#### CONCLUSION:

The percentage was lower in GGT: this lower adherence could be explained by the presence of workers, which could attend less scheduled sessions compared to self-chosen, home training. As reported by Rodrigues (1) two of the main barriers to adherence are lack of time and transport. Indeed, in IHT group, the flexible time-scheduling and no need for transportation improved the adherence to the program. However, there is a positive adherence to the ACTLIFE program for both group. The continuous monitoring of the program and the recommendation of the doctor may have influenced motivation of the participants.

#### References:

(1)Facilitators and barriers to exercise adherence in patients with osteopenia and osteoporosis: a systematic review I. B. Rodrigues<sup>1</sup> & J. J. Armstrong<sup>2</sup> & J. D. Adachi<sup>3</sup> & J. C. MacDermid<sup>4</sup>

## INFLUENCE OF A PERSONALIZED DIGITAL HOME TRAINING ON LEG STRENGTH OF OLDER ADULTS

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### INTRODUCTION:

The lack of a regular muscle-strengthening training poses a health risk, especially for older adults. Thus, research areas such as Active and Assisted Living (AAL) aim at investigating the effect of technologies on older adults' lives. Tablet-based intervention studies, limited by sample size and time, revealed significant improvements on functional performance [1]. However, the mentioned applications mainly focussed on providing training content without feedback or monitoring of exercise execution. Thus, we aimed at investigating the influence of a personalized home strength training called ILSE on older adults' physical fitness from a 14-weeks field trial.

### METHODS:

The AAL solution ILSE consists of a motion promotion app with versions for a 3D camera system (Orbbec Persee) and Android tablets. The home training function is provided on both versions to monitor the number of executed exercises. ILSE on the 3D camera system allows an extended training experience including recognition of postures, counting and notifications of unfavourable postures. 77 healthy older adults (avg 65 yrs) served as ILSE test-group over 14 weeks. Furthermore, leg strength was assessed with the 30-second Chair Rise Test (30s-CRT, number of repetitions/30s) in the test-group and in 127 adults of the control group (n=204 in total) at the beginning and the end of the intervention ( $\Delta$  number of repetitions/30s). Thus, we analysed the difference in functional fitness using Wilcoxon rank-sum test between a control group (CG;n=127), intervention group using solely tablet or camera system (ISG;n=38) and intervention group using both systems for their training (IBG;n=39). Additionally, within the intervention group (n=77) the correlation between number of executed exercises and the change in leg strength was determined using Pearson's correlation coefficient. The significance level was set to 0.05.

### RESULTS:

No significant difference in leg strength was found between intervention and control group. Within the intervention group the change in leg strength was not associated to the number of completed exercises monitored by ILSE. On average ILSE improved the leg strength when using only one training device (ISG: $\Delta$  0.4 $\pm$ 3.2) compared to people using both devices (IBG: $\Delta$  0.1 $\pm$ 2.6), however, no significance could be found.

### CONCLUSION:

Although no group difference could be found yet, this data analysis points toward the necessity to focus on one training device in the development and implementation phase to tailor precise AAL solutions. If the 3D camera system will generate more benefit in establishing a training routine in older adults has to be clarified including the upcoming second 14-weeks trial in the analysis.

1. Dasgupta,D.; Chaudhry,B.; Koh,E.; Chawla, N.V. A Survey of Tablet Applications for Promoting Successful Aging in Older Adults. IEEE Access2016, 4, 9005–9017.

## THE EFFECT OF REPEATED WHOLE-BODY CRYOSTIMULATION ON THE ACTIVITY OF ANTIOXIDANT ENZYMES IN TRAINING AND NON-TRAINING OLDER AND YOUNG MEN

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### INTRODUCTION:

As a result of aging, the activity of antioxidant enzymes decreases, which is counteracted by aerobic training. It is also known that in young people, the daily use of whole-body cryostimulation (WBC) increases antioxidant defense [1,2]. The aim of the authors' research was to assess the effects of WBC, repeated every other day, on the activity of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) in training and non-training older men, compared to its effects in young men.

### METHODS:

The study included 20 older (58.80 $\pm$ 6.22 years) and 20 young males (22.35 $\pm$ 1.73 years). In each of the age groups, there were 10 non-training individuals (60NTR, BMI 27.28 $\pm$ 2.32 kg/m<sup>2</sup>; 20NTR, BMI 23.74 $\pm$ 2.20 kg/m<sup>2</sup>, p<0.01) and 10 subjects training long-distance running (60TR, BMI 24.87 $\pm$ 1.28 kg/m<sup>2</sup>, training experience 6.71 $\pm$ 5.79 years; 20TR, BMI 23.65 $\pm$ 2.51 kg/m<sup>2</sup>, training experience 3.35 $\pm$ 1.83 years). The study participants underwent 24 WBC treatments (3 min, -130°C), every other day. Before the 1st and after 12 and 24 WBC treatments, the activity of SOD and GPx were determined in erythrocytes and CAT in the blood plasma.

### RESULTS:

Prior to the start of WBC treatments, the activity of SOD, CAT and GPx was comparable in the older and younger men (p>0.05), as well as in the 60TR and 60NTR (p>0.05) and 20TR and 20NTR groups (p>0.05). In the 20TR group, SOD activity after the 12th and 24th WBC treatments was higher than the baseline level, by 15% (p=0,01) and 20% (p=0,01), respectively, and at the same time, was higher than in the 20NTR group (p<0.05). CAT and GPx activity did not change in any of the groups under the influence of 12 and 24 WBC treatments.

### CONCLUSION:

Twelve whole-body cryostimulation treatments improve the antioxidant defense in young training men by increasing the activity of superoxide dismutase. Increasing the number of treatments to 24 intensifies this effect. Twenty-four WBC treatments applied every other day do not change the activity of antioxidant enzymes in older men, regardless of their physical activity.

Research funding: National Science Centre, Poland, 2015/17/N/NZ7/01039.

### References:

1. Stanek A., Sieron-Stoltny K., Romuk E., et al. Whole-Body Cryostimulation as an Effective Method of Reducing Oxidative Stress in Healthy Men. Adv Clin Exp Med, 2016; 25, 6, 1281–1291. DOI: 10.17219/acem/65980.
2. Lombardi G, Ziemann E and Banfi G., Whole-Body Cryotherapy in Athletes: From Therapy to Stimulation. An Updated Review of the Literature. Front. Physiol, 2017; 8:258. doi: 10.3389/fphys.2017.00258.

## MINI-TRAMPOLINE JUMPING AS AN EXERCISE INTERVENTION IN POST-MENOPAUSAL WOMEN TO IMPROVE GENERAL HEALTH AND FITNESS

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### INTRODUCTION:

Women tend to outlive men and are at higher risks of functional disability compared to men. Specifically, women are more likely to develop conditions like osteoporosis which can further increase the risk of functional disability. Regular physical activity and exercise programmes can minimize the physiological decline that occurs during aging and can improve overall physical fitness, and bone health; however exercise programmes tend to focus on only one parameter. Mini-trampoline jumping is a beneficial low-impact aerobic exercise capable of improving aerobic fitness, balance, muscle strength and potentially bone health in the elderly. The aim of the proposed research project was to examine the benefits of a 3-months mini-trampoline exercise intervention on physical fitness and bone health in post-menopausal women.

**METHODS:**

38 post-menopausal healthy women (N=8 control & N=30 intervention=30; Age=58.86±5.77 years; Height=163.81±0.06 cm; Weight=77.38±18.52 kg; BMI=28.64±6.31 kg/m<sup>2</sup>) participated in this intervention study. Assessments on physical fitness (aerobic fitness, walking speed, lower extremity strength, flexibility) and bone health were performed within one week before (baseline) and one week (post-exercise) after the exercise intervention, and a 3 month follow-up assessment. The exercise intervention lasted 12 weeks, with three 40-minute sessions per week.

**RESULTS:**

Compared to baseline values, women in the intervention group showed significant improvements in lower extremity strength, walking speed, flexibility, and bone health ( $p < 0.05$ ). Women in the intervention group also showed significantly greater improvement from baseline values compared to women in the control group in resting HR ( $p = 0.019$ ), flexibility ( $p = 0.007$ ), and bone health ( $p = 0.015$ ). No significant differences were found for the intervention group from baseline and post-exercise testing compared to the 3-months follow up for lower extremity strength, walking speed and flexibility. No significant differences were found between groups or between sessions for aerobic fitness and BMI.

**CONCLUSION:**

Although the exercise intervention did not seem to improve aerobic fitness and BMI, significant improvements were found in all of the other assessments. Specifically, bone health results indicate that a mini-trampoline exercise programme may improve sex specific risk factors in older women. Importantly, the improvements seen after intervention did not dissipate in the three months following programme completion. Thus, mini-trampoline exercise may have residual beneficially benefits for lower extremity strength, walking speed and flexibility in women.

### **EVALUATION OF COGNITIVE FUNCTION IN OLDER ADULT WOMEN USING SINGLE- AND DUAL-TASK PHYSICAL EXERCISES: A RANDOMIZED CONTROLLED TRIAL**

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**INTRODUCTION:**

The number of older adults with dementia is rapidly increasing worldwide. The 2019 report "Risk reduction of cognitive decline and dementia" from WHO recommends that people need to change their lifestyles, such as through regular exercise, smoking cessation, and weight management, rather than take medicines or supplements (1). Among them, physical exercise has been associated with improvement in not only physical functions but also various cognitive functions. We conducted a one-year intervention study of single-task (ST) and dual-task (DT) physical exercises to investigate how each exercise affects cognitive function in older adult women.

**METHODS:**

The participants were 39 older adult women (aged 65–81 years, mean±SD: 71.2±3.6 years). The DT group conducted square stepping exercise, whereas the ST group only walked twice a week (total 48 weeks) for 70 to 90 min. The Five Cognitive Tests (The 5-Cog), a screening instrument for detecting cognitive decline among older adults in Japan (2), was used for cognitive function evaluation in this study. The test material (DVD) consisted of performing five elements, such as attention, memory, spatial cognitive ability, language ability, and judgment. The characteristics of participants were compared using two-way analysis of variance (time×group). The effects size (Cohen's *d*) between pre- and post-trial measures was determined by using average change and by excluding the pre-test standard deviation.

**RESULTS:**

The attention item showed significant time×group interaction ( $p = 0.013$ ); the other four items of the 5-Cog showed no significant results. The simple main effect of time in the intergroups was significantly changed in the post-trial measures (DT:  $p = 0.016$ , ST:  $p < 0.001$ ). The post-trial measure of the main effect (time) in both groups was significant ( $p < 0.001$ ). In terms of effect size, ST and DT had the following results:  $d = 0.45$ – $2.27$  (small to large) and  $d = 0.40$ – $1.69$  (small to large), respectively.

**CONCLUSION:**

This study showed significant value in the attention item for time×group interaction between ST and DT. Cognitive function was found to depend on the time of exercise. Therefore, physical exercises in older adult women can improve their cognitive function. The ST group showed better improvement than the DT group: DT did not tend to have a synergy effect on cognitive improvement compared with ST. In the 5-Cog, the learning effect could have been affected by repeated measurement because the same question was asked every time. Therefore, the learning effect may need to be inspected quantitatively, such as through biochemical cognitive function measurement.

1. WHO., Risk reduction of cognitive decline and dementia (2019).

2. M. Sugiyama et al., *The Gerontologist*, (55) 189 (2015).

### **EFFECT OF REGULAR PARTICIPATION IN PHYSICAL FITNESS CHECKUPS ON PREVENTING WEAKNESS AMONG COMMUNITY-DWELLING OLDER PEOPLE IN NORTHERN JAPAN**

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HOKUSHO UNIVERSITY

**INTRODUCTION:**

Health and physical fitness checkups have been encouraged for preventing chronic diseases and functional decline, as well as promoting the awareness of health condition in older people. However, little is known about the beneficial effect of regular participation in physical fitness checkups on preventing frailty or sarcopenia. The purpose of the present study was to demonstrate the relationship between participation in physical fitness checkups and weakness among community-dwelling older people in northern Japan.

**METHODS:**

## CP-MH13 Body dimensions and performance

The subjects were 328 men and 1,531 women aged 60 years and over, who participated in the physical fitness checkups (hereinafter: the checkups) organized by a cooperation project among local municipalities in Hokkaido, northern Japan, a nonprofit organization for social business promotion and Hokusho University in 2019. The checkups have been carried out annually since 2010. Measurements included grip strength, functional reach, sit-and-reach, one-leg standing with open eyes, chair stand and maximum walking speed. Individual attributes, health conditions and lifestyle were also checked using a questionnaire. Weakness was defined by grip strength <26kg for men and <18kg for women, which is a part of the criteria for frailty and sarcopenia by the Asian Working Group for Sarcopenia. The subjects were divided into 3 groups using frequency of participation in the checkups in 2010-2019; only once, 2-3 times and 4 times and more. Multiple logistic regression models having weakness in 2019 as an outcome were used to estimate the association of participation levels in the checkups controlling for age, year and municipalities.

### RESULTS:

The prevalence of weakness in 2019 was 107 (32.6%) for men and 427 (27.9%) for women. The number of subjects in the 3 participation levels; once, 2-3 times and 4 times and more were 93 (28.3%), 138 (42.1%) and 97 (29.6%) in men, and 324 (21.2%), 605 (39.5%) and 602 (39.3%) in women, respectively. In the results of the logistic regression analyses (Odds Ratio; OR and 95% Confidence Interval; CI), women who participated in the checkups more than once were significantly less likely to have weakness (2-3 times: OR 0.65, 95%CI 0.46-0.90, 4 times<: OR 0.57, 95%CI 0.39-0.85). Men showed a similar trend; however, it was not statistically significant (2-3 times: OR 0.83, 95%CI 0.40-1.69, 4 times<: OR 0.55, 95%CI 0.24-1.29).

### CONCLUSION:

Regular checkups may be associated with preserving muscle strength due to awareness of physical fitness condition, and lead to the prevention of frailty and sarcopenia, especially for women. Our results suggest that regular participation in physical fitness checkups may have a beneficial effect on preventing weakness among community-dwelling older people.

## ASSOCIATION BETWEEN PHYSICAL ACTIVITY PATTERNS AND SARCOPENIA IN ARAB MEN

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### INTRODUCTION:

The intensity and duration of daily physical activity may play a significant role in reducing the occurrence of sarcopenia. This study examined the association between physical activity patterns and sarcopenia in Arab men.

### METHODS:

This cross-sectional study included 363 men (47.7 ± 15.4 years), and appendicular lean mass (ALM), handgrip strength test, and physical activity levels were analyzed. ALM divided by the square of height in meters was calculated (ALM/H<sup>2</sup>), and participants with -1 and -2 standard deviations below the sex-specific means for Saudi young adults were considered sarcopenic class I and class II, respectively. Independent t-test, ANOVA, Mann-Whitney U test were performed to determine mean and median differences.

### RESULTS:

The difference between sarcopenic and non-sarcopenic participants in moderate-to-vigorous physical activity (MVPA) was significant (P = 0.04), while correlation between ALM/H<sup>2</sup> and MVPA was borderline significant (P = 0.07). At a one-hour/week in MVPA, the ALM/H<sup>2</sup> increased by 0.30 kg/m<sup>2</sup>. Total and appendicular muscle mass, handgrip strength, and MVPA were significantly lower in participants >60 years (P < 0.001), whereas fat mass and waist circumference did not change as compared to middle-aged participants (P > 0.05).

### CONCLUSION:

MVPA, muscle mass, and strength were lower in older men than that of middle-aged and young men, whereas low physical activity and fat mass did not differ. Future studies should examine the role of MVPA training programs on muscle mass and strength in older men.

## CP-MH13 Body dimensions and performance

### ANTHROPOMETRIC AND BODY COMPOSITION EQUATIONS TO PREDICT RESTING ENERGY EXPENDITURE IN OVERWEIGHT AND OBESE MEN AND WOMEN LIVING IN A TEMPERATE CLIMATE

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### INTRODUCTION:

The resting energy expenditure (REE) is commonly determined by indirect calorimetry. However, in clinical and nutrition settings, it is usually unfeasible and thus prediction equations are employed using anthropometric (ANT) and/or body composition (BC) data. Epidemiological evidence has shown an association between ambient temperature and body weight in humans, and particularly high prevalence of obesity when living in temperate climates. The aim was to develop equations to predict REE of overweight and obese living in a temperate climate all-year round and to determine the accuracy of traditional equations in this population.

### METHODS:

Overweight and obese men and women (n=174) living permanently in Gran Canaria agreed to participate (age: 18-70 yr; BMI>27 kg.m<sup>2</sup>). REE was measured in fasting conditions by indirect calorimetry (Vmax N29). For anthropometric assessment, body weight and height were measured with a balance scale while body composition by DXA. Stepwise multiple regression analysis was used to determine the best predictors of REE in our population by two models (ANT and BC-based). The agreement of our measured REE was compared to the estimation by 20 widely employed ANT-based equations by calculating: bias (absolute values and %), the limit of agreement (LA) (upper LA=bias+1.96xSD; lower LA=bias-1.96xSD), concordance correlation coefficient (CCC). The % of subjects whose predicted REE fell within 10% of the measured REE was taken as a measure of accuracy. Statistical significance was set at p<0.05.

### RESULTS:

In our population, REE can be predicted with the following equations (1=ANT; 2=BD):

$$\text{REE(kcal/d)} = 15.78 \times \text{Weight(kg)} + 169.07 \times \text{sex} + 143.87 \quad (1)$$

$$(R=0.76, R^2=0.58, \text{SEE}=252.7, p<0.001)$$

$$\text{REE(kcal/d)} = 24.91 \times \text{FFM(kg)} + 7.88 \times \text{FM(kg)} + 87.35 \quad (2)$$

FFM=Fat Free Mass; FM= Fat Mass  
(R=0.79, R<sup>2</sup>=0.62, SEE=241.4, p<0.001)

The equations of Mifflin et al. and Livingston et al. gave the best scores of accurate predictions (51% of patients) with non-significant bias of 0.7 and 0.6% and CCC of 0.72 and 0.68, respectively. Out of the 17 additional equations, the Huang et al. and Bernstein et al. equations underestimated (4.8% and 13.0%, respectively), while the other equations overestimated (3.4–15.9%) REE. The equations that did not include obese subjects overestimated REE, except the Henry and Rees equation developed for tropical inhabitants with a non-significant bias (+1.1%).

#### CONCLUSION:

Most equations overpredicted REE in overweight and obese humans living in a temperate climate all year-round and thus we have developed specific equations to predict REE in this population. From the previously existing equations, Mifflin et al. equations gave the most accurate predictions. Reduced thermogenesis in overweight and obese humans living in a temperate climate may contribute to obesity. In agreement, our research gives support to a sustained attenuation of REE in people living in the Canary Islands.

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## RUNNING TRAINING HABITS AND BODY WEIGHT – EPIDEMIOLOGIC SURVEY OF SPORT NEWCOMERS AGED 30 TO 60 YEARS

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#### INTRODUCTION:

Regular running training has many beneficial health effects including the potential to control body weight (1). Furthermore, weight-loss is a frequently stated reason for starting regular physical activities and sports. Especially running is frequently taken up to achieve this goal because it is easy to take up (2). In this context, it is the aim of the current study to analyze training habits and their relationship to body weight in an epidemiologically relevant subsample of newcomers to running.

#### METHODS:

We extracted data from our nationwide survey ([www.dshs-koeln.de/med-pace](http://www.dshs-koeln.de/med-pace)) which collects data from runners registering for running events organized in the German-Road-Races e.V. Survey data is obtained by a scaled questionnaire covering anthropometric parameters (e.g. body weight, body mass index (BMI)), training specifics (e.g. volume, frequency). Cross-sectional data of a subsample from more than 160,000 complete datasets was extracted and analysed. Sample selection criteria were (a) runners aged 30 to 60 years, (b) starting regular running training within the last one to five years and (c) prior to that sporting und running inactivity. ANOVA was used for independent groups.

#### RESULTS:

A total of 11,770 data sets were extracted and data of 7,314 male (m) (41.9±7.3 years; 82.4±11.5 kg; BMI 25.2±3.0) and 4,456 female (f) runners (40.2±7.2 years; 66.3±11.5 kg; BMI 23.5±3.7) were analyzed (mean±s; each p<0.001) in groups by training experience (TE, 1-5 years). Mean TE in years was 3.1±1.2 (m) and 2.9±1.2 (f). Training volume (km/week) increased in an approximately e-functional shape in relation to TE from 14.1±12.7 to 30.2±16.8 km (m) and 11.7±11.1 to 23.1±13.5 km (f) respectively from one to five years TE (p<0.001). In parallel, mean body weight decreases (-5.2 kg (m) and -4.7 kg (f)) with increasing training experience in the TE groups with one through five years from 86.4±13.4 to 81.2±10.5 kg (m) and from 69.2±13.8 to 64.5±9.5 kg (f) (p<0.001). Corresponding mean BMI values vary between 26.4±3.9 to 24.9±3.7 kg (m) and 24.6±4.6 to 22.9±2.9 kg (f) respectively (p<0.001).

#### CONCLUSION:

Of course, the interpretation of these results and all drawn conclusions are subject to the well-known constraints of cross sectional approaches concerning causality. Moreover, analyzed survey data may differ from data obtained by anthropometric measurements. Nevertheless, these results from an extensive sample size suggest systematic long-term effects of regular running training on body weight. Additionally, results imply that formerly inactive, middle-aged subjects are motivated and able to realize progressive training regimes. Together, these results reinforce the view about the enormous protective potential of regular training for ambitious sport beginners and returners to sport activity even later in life.

#### References

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2. Leyk et al. (2017) Journal of Science and Medicine in Sport 20S: S33

## DOSE-EFFECT ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND BODY COMPOSITION OF THE ELDERLY IN CHINESE URBAN-RURAL JUNCTION

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#### INTRODUCTION:

The World Health Organization (WHO) recommends the elderly should have at least 75 vigorous or 150 moderate intensity minutes per week (600 MET min/week) of physical activity. This research is to quantify the accurate dose-response association between leisure time physical activity (LTPA) and body composition of the elderly in Chinese rural-urban junction area and find the threshold that will improve different body composition index.

#### METHODS:

We conducted a sample survey of old people in a rural-urban junction in East China. We designed "Questionnaire of PA of the Elderly in Chinese Rural-Urban Junction" (with reliability and validity test), and acquired LTPA and divide subjects into 7 LTPA level groups.

We measured subjects' bone density Z value, bone mass, muscle mass and fat content respectively by ultrasonic bone densitometer and Tsinghua BCA-2A Body Composition Analyzer.

#### RESULTS:

Compared with males reporting no LTPA, we observed a 0.43 unit higher Z value among males who performing less than the minimum recommendation (0-1 REC), a 0.52 unit higher at 1-2 REC, a 0.63 unit higher at 2-4 REC, A highest threshold for bone density benefit occurred at 4-6 REC. More than 6 REC, the benefit slows down, but Z value is also higher than baseline. The similar trend occurred in females. There is a similar dose-effect relationship in bone mass index.



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About muscle mass, despite the benefit begin decreasing at 4-6 REC, it is also higher than baseline. Even the LTPA exceed 10 REC, muscle mass is also 1.96kg higher than baseline in males and 4.31kg higher in females.

The body fat percentage of males are always lower than females. It's decreasing continuously with the increase of LTPA. In males, when LTPA increase to more than 10 REC, it is 28.59%, 2.90% lower than baseline. In females, it is 29.95%, 4.07% lower than baseline.

CONCLUSION:

In the elderly of Chinese rural-urban junction area, females are more active than males in leisure time physical activity. Increasing leisure time physical activity can effectively improve body composition index in both male and female. 4-6 times minimum recommendation (4-6 REC) is the best amount of LTPA to improve bone mass and muscle mass. As for body fat percentage, more LTPA will bring more benefits. Therefore, on the aspect of improving the body composition, the recommended amount of leisure time physical activity of the elderly in the urban-rural junction area should be adjusted accordingly.

### RELATION BETWEEN BODY COMPOSITION AND MAXIMUM OXYGEN UPTAKE IN SWISS ATHLETES: A CROSS-SECTIONAL STUDY OVER A PERIOD OF 20 YEARS.

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CLINIQUE ROMANDE DE RÉADAPTATION

INTRODUCTION:

Assessment of body composition and physical fitness of athletes is considered as an important part of a performance training process. Knowing these reference values according to age, sex and type of sport would be of great interest for the coaches and the athletes for goal setting and planning.

The study aims to characterize the maximum oxygen uptake ( $\dot{V}O_2$  max), percentage body fat (PBF), total fat mass (TFM), fat-free mass (FFM) according to age, gender and type of sport in a large cohort of Swiss athletes and to explore the relationship of physical fitness with body composition characteristics.

METHODS:

From 1999 to 2019, the study included 746 athletes (525 men and 221 women) with mean age of 35 years (standard deviation of 10.4 years) who had  $\dot{V}O_2$  max above the 95th percentile according to American College of Sport Medicine's Guidelines for Exercise Testing and Prescription. Body composition was assessed by air displacement plethysmography (BOD POD, Concord, CA, USA).  $\dot{V}O_2$  max was measured by using either an incremental bicycle or treadmill test. Direct oxygen uptake and carbon dioxide production were measured breath-by-breath with a gaz analyzer (Metalyzer, Cortex, Leipzig, Germany). PBF, TFM, FFM and  $\dot{V}O_2$  max were stratified by age, sex and type of sport. The sport disciplines were: running (30%), alpine ski (25%), road cyclists (15%), mountain cyclists (11%) and others (19%). Relationships between  $\dot{V}O_2$  max and the body composition variables were explored in univariate and multivariate analysis.

RESULTS:

Mean  $\dot{V}O_2$  max values is statistically higher in men than in women (59.8 versus 52.1 ml/kg/min;  $p < 0.001$ ). Women displayed a higher value of PBF and TFM than men (22.0% versus 14.1%,  $p < 0.001$ ; 12.5 kg versus 10.2 kg,  $p < 0.001$ , respectively) and a lower value of FFM than men (44.2 kg versus 61.7 kg,  $p < 0.001$ ). Differences in mean PBF, TFM and FFM were observed by sex and sport disciplines ( $p = 0.01$ ). Athletics displayed the lowest PBF (10.7% in men and 19.1% in women). Men cyclists displayed the highest  $\dot{V}O_2$  max (62.8 ml/kg/min) and women mountain bike displayed the highest  $\dot{V}O_2$  max (54.7 ml/kg/min). There was a gradual decrease of mean  $\dot{V}O_2$  max and an increase of mean PBF by increasing age. In the univariate analysis, PBF showed strongest negative correlation ( $r = -0.59$ ,  $p < 0.001$ ) with  $\dot{V}O_2$  max. Taken the age, sex and PBF as predictors in multiple regression analysis, the model explained 51% the variance of  $\dot{V}O_2$  max.

CONCLUSION:

These results showed important difference of body composition and physical fitness according to age, gender and type of sport. As PBF is the only modifiable factor, it is of importance that the athletes maintain a good lifestyle in order to optimize their cardiorespiratory fitness, hence their performance.

## CP-MH14 Physical activity: Cancer and chronic diseases

### “DOSING AND FEASIBILITY OF PHYSICAL EXERCISE INTERVENTIONS IN PATIENTS WITH ADVANCED-STAGE CANCER”

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ASOCIACIÓN ESPAÑOLA CONTRA EL CÁNCER

INTRODUCTION:

It is well known that physical activity improves fatigue, quality of life and wellbeing in cancer patients and reduces treatments side effects (1)

However, there is no much knowledge about the dose and feasibility of physical exercise for cancer patients in advanced or metastatic stage. This review aimed to identify and summarize the most effective doses of physical exercise in this kind of patients.

METHODS:

A literature search was performed using two electronic databases: PubMed and Web of Science, to identify relevant papers published before March 1, 2020. Papers reporting randomized control trials, conducted in adult cancer patients in advanced or metastatic stage during and/or after cancer treatment. In order to know the quality of the studies, Physiotherapy Evidence Database Scale (PEDro) was used.

RESULTS:

The search identified 104 potentially relevant papers, of which 21 fulfilled the eligibility criteria. In these 21 studies, 1536 patients were included. All the patients were over 18.

CONCLUSION:

Although physical intervention varies among trials, the studies shown that physical exercise is a feasible, effective and indispensable tool for cancer patients in advanced stages which reduces treatment's side effects like fatigue, muscle mass lost, fitness capacity or sleep disturbances. Moreover, different exercise modalities and intensities has been effective to achieve main objective in different studies, suggesting that exercise dose-response must be adapted to every patient objective and necessities

Exercise intensity impacts directly in patients' adherence, suggesting that moderate intensity is related with better adherence than others.

Regarding to objective achievement, longer interventions (more than 12 weeks) are related to better rates of getting the program aims. It suggests that supervised exercise intervention create high rates of adherence not only for the activity as well as for the social environment where the intervention is developed.

As decreased cardiovascular capacity and loss of muscle mass are two of the most acute side effects because of cancer treatments, multi-modal exercise has proved to be the most effective intervention.

Finally, regarding to the physical intervention design it is important to take into account that although it is an unstable and volatile population, there are some factors that should be considered to achieve better ratios of successful in this type of programs such as supervised interventions of strength or combined exercise, lower frequency of 3 days per week and moderate intensity.

In addition, other important aspects as socio-demographic factors, physical, physiological and behavioral factors should be taken into account to raise the adherence.

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### ACUTE AND CHRONIC FATIGUE FOLLOWING A 8-WEEK SUPERVISED EXERCISE PROGRAM IN CANCER PATIENTS.

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(A) UNIVERSITÉ DU MANS (B) UNIVERSITÉ SAVOIE MONT BLANC

#### INTRODUCTION:

Cancer-related fatigue (CRF) is defined as a distressing, persistent, subjective sense of physical, emotional and cognitive tiredness or exhaustion related to cancer or cancer treatment that is not proportional to recent activity and interferes with usual functioning in patients<sup>1</sup>. Conversely, acute fatigue refers to a neuromuscular function decrease due to an exercise and reversible with appropriate recovery. Neuromuscular function is impaired during and after cancer treatment. Moreover, exercise is known to reduce both chronic (CRF) and acute neuromuscular fatigue. However, it is unclear whether a link exist between acute and chronic fatigue nor reducing acute fatigability will have a causal effect on chronic fatigue. The aim of this study was to analyse the potential link of causality between acute and chronic fatigue by means of a supervised exercise program in cancer patients.

#### METHODS:

Twenty women with breast and ovarian cancer aged from 37 to 68 years volunteered to participate in this study. The study consisted in two identical experimental sessions before and after an 8-week supervised physical exercise program. For each experimental session, CRF were assessed using the FA12 questionnaire. Patients with a score >25 were considered to suffer from CRF. Acute fatigability was quantified by the estimation of handgrip maximal force (Fmax), critical force (FCr) and impulse above critical force (W') using a 5 min all-out exercise (60 maximal voluntary contractions of 4s interspersed by a 1-s rest). The supervised exercise program took place for 8 weeks (1h/week), consisted of strengthening exercises, stretching and postural exercises. The exercise intervention will be delivered by exercise specialist.

#### RESULTS:

W' tended to be significantly different between patients with and without CRF (p=0.06). However, CRF patients decreased their W' between T0 and T1 while that of patients without CRF improved. In addition, FCr exhibited a significant improvement (p<0.05) between T0 (10.9±3.1 for NF and 11.2±3.4 for F) and T1 (11.3±2.5 for NF and 12.6±4.7 for F). Finally, PC has reduced the number of tired patients (10 at T0 and 6 at T1).

#### CONCLUSION:

On the one hand, whether the patient presented CRF or not, Fmax and FCr were the same for both groups. In contrast, a patient with CRF has a W' which tends to be lower than patients without CRF. On the other hand, exercise intervention, for 8-weeks, has shown an increase in FCr for patients with and without CRF and a decrease in the number of patients with CRF. However, after the exercise intervention, we observe an inverse effect of W between patients with CRF and patients without CRF. In fact, the patients without CRF improved it while W' decreased in patients with CRF.

### MUSCLE VISCOELASTIC CHARACTERISTICS AROUND THE SHOULDER BEFORE AND AFTER TRAINING INTERVENTION IN BREAST CANCER SURVIVORS

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UNIVERSITY OF URBINO CARLO BO

#### INTRODUCTION:

Upper limb morbidity (e.g. lymphedema, pain, and range of motion restrictions) are well-known consequences of treatment of Breast Cancer (BC), however mechanical properties of muscles around the shoulder in BC patients are not well known. No studies investigated the effect of exercise training in mechanical properties of BC patients, 6-month after surgery. Here we study how the viscoelastic characteristics of muscle around the shoulder (non-neural tone, elasticity and stiffness) vary as a function of the surgery side and after exercise training interventions within the Italian project *MoviS*: 'Movement and Health Beyond Care' (Ethical Committee n. 21/2019) a randomized controlled trial, aims to educate BC patients on the benefits of exercise and proper nutritional plan.

#### METHODS:

Thirty women with stage 0-III non-metastatic BC recruited 6-month post-surgery, receiving adjuvant therapy (age: 53.5±7.6; BMI: 25.3±4.9) were randomized in two groups of fifteen women: intervention arm (IA) received 3-month aerobic training 3 day per week with increase of exercise intensity (40-70% HRR) and duration (20 to 60 min); or control arm (CA) that received only usual care recommendations. A non-invasive measurement device called *MyotonPro* was used to measure pre and post intervention the tone, stiffness, and elasticity in the sternocleidomastoid, biceps brachii, upper trapezius and pectoralis major at rest. Statistical analysis was performed using generalized linear model; considering as dependent variables viscoelastic characteristics of muscles above listed vs group membership and arm; all measurements were executed in pre and post training conditions; all elaboration were performed on SPSS 24.0.

#### RESULTS:

Considering differences pre-post (t0-t1, within factor), both the tone and stiffness are significantly different (p<0.001), while the elasticity does not vary overall significantly (p=0.708). When comparing pre-post variations in the two groups (IA and CA), it is shown that the tone is significantly different (p=0.018), while both stiffness (p=0.481) and elasticity (p=0.646) are not different between the two groups. Consider-

ing the difference in viscoelastic characteristics between the muscles of the operated side and the contralateral one, the tone was significantly different ( $p=0.040$ ), while there were no variations in stiffness ( $p=0.313$ ) and elasticity ( $p=0.839$ ).

**CONCLUSION:**

BC survivors whose benefit of exercise by the Movis Project have shown differences in the non-neural tone in the muscle around the shoulder between the operated side vs. the healthy one. Exercise training intervention both recommended that supervision affected the tone and stiffness; however, supervised training protocols showed better improvement in the tone of all muscle tested. The results obtained on the muscle assessment in the Movis BC patients support the relation between physical activity and health status in these delicate subjects.

**BREAST CANCER BRCA 1/2 MUTATIONS: BASELINE EVALUATIONS OF PHYSICAL ACTIVITY, SLEEP QUALITY, AND CHRONO-TYPE**

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**INTRODUCTION:**

Physical activity (PA) is an important tool involved in the sporadic breast cancer (BC) prevention. PA could modulate the risk factors in the majority of sporadic BC. Recently, sleep quality has been considered as an environmental risk factor for BC. BC is classified not in only sporadic BC, but also in genetic BC [1]. The mutations in BRCA1 and BRCA2 genes (BRCA1/2) are the most known genetic causes for hereditary BC. Unlike sporadic BC, there is still a lack of evidences about the role of PA on genetic BC. Recently, studies provided preliminary support for a protective role of PA against BC among BRCA1/2-mutant women, particularly if occurring during adolescence. Aim of the present study was to investigate the role of PA on BC risk factors and on sleep quality in women carrying BRCA1/2 mutations [2].

**METHODS:**

Preliminary data analysis involved 45 women ( $48.5\pm 12.4$  yrs) with BRCA1/2 mutations, who have or not already developed BC (BRCA-withBC and BRCA-withoutBC) and in care at Fondazione IRCCS – Istituto Nazionale dei Tumori, Milan. The participants filled in: Godin-Shepard Leisure-Time Physical Activity Questionnaire (GSLTPAQ), Pittsburgh Sleep Quality Index (PSQI) and reduced Morningness-Eveningness Questionnaire (rMEQ) for the evaluation of the PA level, sleep quality, and chronotype, respectively. Moreover, they underwent to anthropometric, metabolic, and blood sample evaluations. Data were analyzed with STATA 12 statistical package.

**RESULTS:**

The total sample was classified: active (GSLTPAQ =  $29.7\pm 19.1$ ) and bad sleeper (PSQI =  $6.8\pm 3.7$ ). Evening-types were found only among BRCA-withBC group. The BRCA-withBC group ( $n=30$ ) was classified: inactive ( $23.7\pm 16$ ) and bad sleeper ( $7.3\pm 3.4$ ); no differences were highlighted in the anthropometric and metabolic values between active and inactive women. The BRCA-withoutBC group ( $n=15$ ) was classified: active ( $35.7\pm 33.3$ ) and bad sleeper ( $6.2\pm 4$ ); active women reported better anthropometric (waist circumference,  $p\leq 0.04$ ) and metabolic (glycemia,  $p\leq 0.009$ ; triglycerides,  $p\leq 0.01$ ; insulin,  $p\leq 0.007$ ) parameters. Among active subjects, the LDL and insulin showed better values in the BRCA-withoutBC group ( $p\leq 0.02$ ,  $p\leq 0.02$ , respectively).

**CONCLUSION:**

These preliminary data indicated a positive relation between higher levels of PA and some anthropometric/metabolic parameters, particularly in the BRCA-withoutBC group that is the most active group. However, not all participants reached a sufficient PA level, suggesting that a structured PA intervention is needed to try to modulate the penetrance of genetic BC and to improve sleep behaviors.

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**EFFECTS OF A SUPERVISED PHYSICAL EXERCISE PROGRAM ON BODY COMPOSITION, CARDIORESPIRATORY CAPACITY AND STRENGTH, AS PART OF TREATMENT FOR CANCER PATIENTS**

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DEUSTO UNIVERSITY

**INTRODUCTION:**

The physical exercise plays a relevant role on the oncological treatment inasmuch as the negative impact of the secondary effects of the treatment in the cardiorespiratory value, levels of strength and muscle mass and body composition among others (Hayes et al. 2019).

The aim of this study was to evaluate the effects of a three months supervised exercise program on body composition, cardiorespiratory capacity and strength of cancer patients during their medical treatments.

**METHODS:**

26 patients (age  $55,62\pm 10,91$ ; weight  $70,16\pm 13,93$  kg; height  $162,58\pm 9,96$  cm; % body fat mass  $36,10\pm 7,13\%$ ) who participated in a large clinical trial launched by Biocruces research group with the collaboration of the Basque public health services (Bizkaia, Spain) were evaluated in this study. Patients were prescribed exercise by their doctors and sent to the program. The clinical trial consisted of three months (3M) of supervised physical exercise (EX) or control (no supervised exercise, CO) and patients were randomized to one of the two groups after the initial physical evaluation (0M). This evaluation consisted of battery of exercises aimed to measure body composition [lean muscle mass, M (kg)], cardiorespiratory capacity (watts (W) at anaerobic threshold, VT2), and the upper and lower body strength [UBS, LBS (kg)]. The evaluation was undertaken again at the end of the three months. From  $n=26$ ;  $n=21$  were women and  $n=5$  were men;  $n=22$  solid and  $n=4$  hematological cancer, 14 were assigned to CO and 12 to EX.

**RESULTS:**

There were no significant differences between EX and CO in the 0M. There were significant differences between EX and CO at the 3M on VT2 (EX:  $113.6\pm 40.1$  W; CO:  $74.1\pm 13.8$  W,  $p<0.01$ ) and LBS (EX:  $83.7\pm 27.1$  kg; CO:  $58.6\pm 24.8$  kg,  $p=0.02$ ); but not on M (EX:  $25.1\pm 5.8$  kg; CO:  $23.1\pm 4.9$  kg,  $p=0.35$ ) and UBS (EX:  $44.9\pm 18.7$  kg; CO:  $31.7\pm 14.9$  kg,  $p=0.06$ ). Finally, there were no significant differences in any variables from 0M to 3M on CO. However, EX had significantly higher values between 0M and 3M on M ( $24.6\pm 5.8$  kg to  $25.1\pm 5.8$  kg,  $p=0.01$ ), VT2 ( $81.8\pm 24.8$  W to  $113.6\pm 40.1$ ,  $p<0.01$ ), UBS ( $35.4\pm 18.9$  kg to  $44.9\pm 18.7$  kg,  $p<0.01$ ), and LBS ( $64.9\pm 36.7$  kg to  $83.7\pm 27.1$  kg,  $p=0.02$ ).

**CONCLUSION:**

These data suggest that supervised exercise as part of treatment for cancer patients improves their overall physical status. Even with the small sample evaluated in this study, data supports the need for a regular, systematic and supervised exercise programs together with the traditional medical treatment prescribed by the doctors.

#### WHY DO COPD PATIENTS GET SO BREATHLESS WALKING UPHILL ?

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##### INTRODUCTION:

COPD patients often complain of severe dyspnea when walking uphill, even with a mild incline. We hypothesized that this dyspnea is out of proportion to the increased work necessary to overcome gravity when walking uphill.

##### METHODS:

Eight COPD patients (median FEV1 45% predicted, range 33-72%), performed 3 symptom-limited exercise tests, in random order, on a treadmill, each at a fixed grade: 1%, 2.5% and 4%. Treadmill speed was increased stepwise (3'/stage). Subjects reported dyspnea according to the Borg scale (1-10 points) at each stage. Cardiac, respiratory and gas exchange response was continuously recorded. An inspiratory capacity (IC) maneuver was performed during the last minute of each stage. Peak oxygen consumption ( $\dot{V}O_2$ ) was determined for each test. Borg score reported by each subject at a uniform level of oxygen consumption ( $\text{iso}\dot{V}O_2$ ), corresponding to the lowest  $\dot{V}O_2$  attained in the 3 tests performed by the subject, was compared across tests by Friedman's repeated-measure non-parametric ANOVA. Parameter values were linearly interpolated as necessary.

##### RESULTS:

COPD patients were more dyspneic when walking at higher grades, despite correction for level of oxygen consumption: at  $\text{iso}\dot{V}O_2$ , dyspnea increased with treadmill grade ( $P < 0.01$ , Friedman's test; post-hoc Dunn's test:  $p < 0.05$  for 1% vs. 4% grade). The median increase in Borg score, at  $\text{iso}\dot{V}O_2$ , from 1% to 4% grade, was 1.3 points (range: -0.1 to 3.9).

Severity of dynamic hyperinflation, at  $\text{iso}\dot{V}O_2$ , increased with grade, as reflected by decrease in IC during exercise: median -315ml, range -750 to 300ml at 1% grade vs. -585ml (-870 to 160ml) at 2.5% vs. -590ml (-930 to -220ml) at 4% ( $P < 0.005$ , Friedman's test; post-hoc Dunn's test:  $p < 0.05$  for 1% vs. 4% grade).

##### CONCLUSION:

Walking uphill per se increases breathlessness of COPD patients, even at  $\text{iso}\dot{V}O_2$ , suggesting that the increased dyspnea cannot be explained simply by the increased work. This finding may be a result of the dynamic hyperinflation, which is worse at steeper inclines. Further studies will be necessary to elucidate the mechanism of this phenomenon. Possibilities include an effect of posture; or of gait, perhaps altering afferent output from leg muscles to the respiratory centers in the brain.

#### THE FEASIBILITY OF DIFFERENT EXERCISE MODES AND INTENSITIES IN PEOPLE WITH EARLY RHEUMATOID ARTHRITIS: A PILOT STUDY

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##### INTRODUCTION:

Exercise is advocated in the treatment of rheumatoid arthritis (RA) [1] and yet there is limited information for exercise prescription, especially for people with a recent diagnosis. It is currently unknown if people with early RA can even tolerate meaningful exercise and what the acute effects will be from varying exercise modes and intensities. This study examined the feasibility of aerobic and resistance-based exercise in people with early RA.

##### METHODS:

Following local NHS ethical approval, ten participants with early RA (Age=46±13years; BMI=29.4±8.6kg/m<sup>2</sup>, RA diagnosis=13±9months, mean±sd) were enrolled and currently four participants have completed the study. Inclusion criteria were RA diagnosis (2010 EULAR criteria) within the last two years and not engaging in regular physical activity (i.e. no participation in structured exercise >2 times per week in the preceding 3 months). Participants were assessed for maximal aerobic capacity ( $\dot{V}O_{2\text{max}}$ ) and maximal strength at chest press, leg press and wide-grip lateral pulldown using a 4-6 repetition maximum (RM) protocol. Thereafter they completed one no-exercise control trial (CON) and four exercise trials: 1) 30 minutes of sub-maximal cycling at a workload equivalent to 65%  $\dot{V}O_{2\text{max}}$  (CYCLE); 2) high intensity interval exercise consisting of 10x1 minute cycling intervals at a workload equivalent to 95%  $\dot{V}O_{2\text{max}}$  (HIIE); 3) resistance exercise consisting of three sets of 12-15 repetitions at 70%1RM (RES-70); 4) resistance exercise consisting of three sets of repetitions to failure at 30%1RM (RES-30%). Exercise trials were randomised and separated by a washout period of 3-7 days. Participants completed a visual analogue scale (VAS) for pain at baseline, 2- and 24-hours post exercise; they also completed a questionnaire related to exercise enjoyment 2- and 24-hours post exercise.

##### RESULTS:

Participants completed the prescribed exercises in full; heart rate was 16% higher during HIIE compared to CYCLE (156±22bpm vs 134±17bpm). Total weight lifted during RES-30 was 147% and 94% higher compared to RES-70 in leg press and wide-grip lateral pulldown, whilst total weight lifted was 5% higher during RES-70 in chest press. All participants enjoyed the exercises with comparable high results across the exercise conditions (CYCLE=87.4±0.9; HIIE=86.6±2.3; RES-70=89.8±2.1; RES-30=86.8±2.5, enjoyment scored 17-119) and exercise did not increase pain acutely (VAS pain baseline: 0.1±0.3; VAS 2 hours=0.7±0.4; VAS 24 hours=1.2±0.8, VAS scored 0-10).

##### CONCLUSION:

This study has identified that people with early RA can tolerate varying exercise modes and intensities. High exercise intensities and resistance loads do not increase pain perceptions and are enjoyable for these people. Therefore, these findings may have significant implications for exercise prescription in RA.

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## CP-MH16 Prevention and rehabilitation

### CRITERION-RELATED VALIDITY OF FIELD-BASED FITNESS TESTS IN ADULTS. THE ADULT-FIT STUDY.

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#### INTRODUCTION:

Physical fitness is considered a powerful marker of health in adults (Barry VW et al., 2014; Garcia-Hermoso A et al., 2018). Field-based fitness tests are considered a useful and reasonable alternative of laboratory tests. It would be desirable to summarise the criterion-related validity of the existing field-based fitness tests in adults. The objective of this systematic review was to comprehensively study the criterion-related validity of the existing field-based fitness tests used in adults.

#### METHODS:

Relevant studies were systematically searched from Web of Science and PubMed electronic bibliographic databases until December 2019, by two authors. Original studies and systematic reviews were scored according to quality assessment lists, and each study was classified as high, low and very low quality. Three levels of evidence were constructed: strong evidence, moderate evidence and limited evidence. The methodology applied followed the guidelines drawn in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher D et al., 2009).

#### RESULTS:

From 7713 eligible studies, 100 original studies and 4 systematic reviews were analysed. There was strong evidence indicating that the 20-m shuttle run, 1.5-mile, 1-mile, 2-km walk, 12-minute walk/run, 6-minute walk, and step tests are valid tests to estimate cardiorespiratory fitness; handgrip strength test is a valid measure of isometric muscular fitness. However, there was strong evidence indicating that the different protocols of sit-and-reach test are not valid to assess flexibility. We found moderate evidence that the Biering-Sørensen and plank tests are valid tests to estimate trunk endurance muscular fitness. A large number of other field-based fitness tests presented limited evidence, mainly due to a limited number of studies (1 for each test).

#### CONCLUSION:

Several cardiorespiratory fitness field-based tests are an alternative of direct assessment of individual's maximum oxygen consumption when it is not feasible. The handgrip test is valid to assess isometric muscular fitness. Many high quality studies are necessary to assess the criterion-related validity of explosive and endurance muscular strength, flexibility and motor fitness field-based tests in adults.

### CARDIO METABOLIC RISK FACTORS AND COGNITIVE FUNCTIONS IN 10-11 YEAR OLD CHILDREN.

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#### INTRODUCTION:

Rapid increase of obesity in children and adolescents is alerting health problem. Furthermore, clustering of cardio-metabolic risk factors (CMRF) lead to impairment of physical and mental health. Early detection and treatment is likely to reduce morbidity and mortality from CM diseases and improvement of cognitive functions (CF). Aim of the study was to evaluate the impact of Body Mass Index (BMI) on various CMRF, including fitness level (FL). In addition, relations between FL and CF were assessed.

#### METHODS:

96 4th grade students were enrolled in the PACH study and based on WHO BMI percentile scale 5 study groups were formed: underweight (UW), till 50th percentile (N50), till 85th percentile (N85), overweight (OW) and obese (OB). Fitness level (FL) was assessed with 3-min Kasch Pulse Recovery Test (1–excellent; ... 6–very poor). Lipid profile and characteristic glucose homeostasis biomarkers, and Hs-CRP levels were determined by E.Gulbis clinical laboratory. Cognitive functions were assessed by Vienna Test System. One way ANOVA for comparison of groups (mean±SEM) was used. Data were analyzed with SigmaPlot12.5.

#### RESULTS:

FL was significantly worse in OB compared to N50 (UW:2.3±0.3; N50:2.1±0.2; N85:2.3±0.2; OW:2.5±0.3; OB:3.5±0.3). Systolic blood pressure (SBP) was higher in OB group when compared to UW, N50 and N85, while there was no difference between OB and OW groups (UW:98±4; N50:100±2; N85:101±2; OW:103±2; OB:116±3). TAGs were increased in OB and OW compared to N50 (UW:0.7±0.1; N50:0.6±0.1; N85:0.7±0.5; OW:1.0±0.2; OB:1.0±0.1 mmol/l), while there were no differences in other markers of lipid profile. There was significantly higher insulin and C-peptide levels and HOMA-IR values in OB when compared to UW, N50 and N85. There were no differences in glucose or Hb A1c levels between the five groups. Also Hs-CRP was higher only in OB group compared to UW, N50 and N85. (UW:0.4±0.1; N50:0.5±0.1; N85:0.4±0.1; OW:1.9±0.6; OB:2.6±0.7 mmol/l). There were significant ( $p < 0.05$ ) correlations between FL and SBP, Hs-CRP, glucose, insulin, HOMA-IR, C-peptide, TAG, LDL and noneHDL levels. In addition, there were relations between FL and such DT (cognitive function test) parameters as, correct responses and median reaction time, which measure reactive stress tolerance and the associated ability to react.

#### CONCLUSION:

Only children with obesity have significantly increased CMRF, although similar tendency is seen also in overweight children. These CMRF are inversely related to FL in children. In addition, improved FL is also related to better cognitive functions, more specifically, individual's ability to utilise modes of behaviour that enable to cope with situation as effectively as possible.

### MONITORING VELOCITY LOSS DURING RESISTANCE TRAINING IN INSTITUTIONALIZED ELDERLY PEOPLE

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#### INTRODUCTION:

Over the last decade, a new methodological approach based on the control of movement velocity has been proposed to quantify the resistance training (RT) load [1]. Several studies, specifically with trained young adults, showed that monitoring movement velocity during RT can be a useful tool to determine true training load [2]. However, to the best of our knowledge, no study has analyzed the impact of this

training method in elderly people. Therefore, the purpose of the current study was to compare the effects of two RT programs with the same relative load (40-65% of the 1-repetition maximum [1RM]), but different velocity loss (VL), 10% (VL10) vs. 20% (VL20), on the maximum dynamic strength in institutionalized elderly people.

#### METHODS:

Sixty-five subjects (78.6 ± 7.2 years old) were randomly assigned into three groups: VL10 (n = 21; 8 males), VL20 (n = 21; 8 males) or control group (CG; n = 23; 8 males). Over 10-weeks, the VL10 and VL20 performed two RT sessions per week and the velocity of each repetition was monitored using two main exercises: horizontal leg-press (LP) and seated chest-press (CP). The CG maintained their normal daily routine. The primary outcome measure was the estimated 1RM in the LP and CP. The VL10 and VL20 were assessed at pre, mid and post-test, while the CG was assessed at pre and post-test.

#### RESULTS:

At baseline, no significant differences in the LP and CP were observed among the three groups. After 10-weeks, significant differences between VL10 and CG in the LP ( $p < 0.01$ ) and CP ( $p < 0.01$ ) were observed, as well as between VL20 and CG in the LP ( $p < 0.05$ ) and CP ( $p < 0.05$ ). The VL10 and VL20 significantly improved their 1RM in the LP and CP from pre to mid-test ( $p < 0.01$ ), from mid to post-test ( $p < 0.05$ ) and from pre to post-test ( $p < 0.001$ ). No significant differences between VL10 and VL20 in the LP and CP in any time period were observed. In the VL10, the total number of repetitions in the LP was 254.0 ± 37.1 and 247.8 ± 28.0, while in the CP was 192.3 ± 33.1 and 189.0 ± 26.6 for men and women, respectively. In the VL20, the total number of repetitions in the LP was 516.6 ± 65.8 and 479.3 ± 64.0, while in the CP was 348.9 ± 54.5 and 324.0 ± 54.4 for men and women, respectively.

#### CONCLUSION:

The results of this study seem to indicate that two different magnitudes of VL induce similar maximal dynamic strength gains in elderly people. Nevertheless, the total amount of repetitions executed by the VL10 group was approximately half the total number of repetitions performed by the VL20 group, which indicates that a low VL is enough to induce significant strength gains in elderly people.

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### DOES THORACIC POSTURE CORRELATE TO BALANCE SCORES IN ELDERLY ADULTS?

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#### INTRODUCTION:

The purpose of this study was to determine if a relationship existed between thoracic posture and static balance scores among the elderly population. Balance is the even distribution of weight enabling someone or something to remain upright and steady (1). Balance is an essential part for all daily activities, especially in the older population. There is evidence that proves that balance scores are associated with affecting rates of falls (2). There are also studies that show there is a direct correlation between the prevalence of falls and the increase of age (3). The increase of falling in the elderly population shows that as a person ages, their balance controls tend to decrease. Posture tends to regress in the older population due to gravity and loss of Type 2 muscle fibers in the thoracic region of the body (4). Currently, there is no literature demonstrating if a relationship exists between these variables.

#### METHODS:

14 male and female seniors volunteered for this investigation (age yr. 82.29±/ 9.71, height 64.78±/ 6.22 cm, mass 77.66±8.25 kg) from a local independent retirement community. Their torso photo was obtained in order to configure their degree of posture through the use of a phone application called PosturescreenTM to measure thoracic posture. Head angle degree, left shoulder degree, right shoulder degree, left pelvis degree, and right pelvis degree were measured and tabulated on Excel. Center of pressure (CoP) measurements were taken with the eyes open stable surface (EOSS), eyes closed stable surface (ECSS), eyes open perturbed surface (EOPS), and eyes closed perturbed surface (ECPS) using a Bertec Computerized Posturography Plate. A Pearson correlation coefficient was selected to analyze for any relationships.

#### RESULTS:

Pearson correlations (SPSS version 24) between the thoracic posture scores and the Center of Pressure (CoP) scores were not strong (EOSS  $r = 0.2118$ ; ECSS  $r = 0.0077$ ; EOPS  $r = 0.2555$ ; ECPS  $r = 0.0917$ ).

#### CONCLUSION:

This study did not show any strong relationship between thoracic posture and balance scores in older adults. Limit of Stability (LoS) could have been measured to determine if these balance scores would demonstrate a strong relationship. Limitations include using sample size, age, and time of day. Further research could look into other posture related scores such as the neck or lower back and balance scores in the elderly population.

### EVALUATION OF AN EXERCISE PREVENTION PROGRAM TO REDUCE PHYSIOLOGICAL STRAINS IN ELDERLY CARE NURSES

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#### INTRODUCTION:

Elderly care nurses frequently perform transferring tasks under time pressure and in awkward body postures. This results in a high disposition for musculoskeletal disorders [1]. Due to the manifold demands on the musculoskeletal system, programs to reduce physical strains and to prevent musculoskeletal disorders are necessary. The aim of this study is to examine whether a prevention program including a tailored ergonomic-training (BASE program) [2] and back fitness shows benefits to reduce perceived physical strains and musculoskeletal pain of the participants.

#### METHODS:

The non-randomized controlled study included n= 56 nurses (age: 43.9±9.3 years) in the intervention group and n= 145 nurses (age: 41.5±12.1 years) in the control group. The effects of a 22-week prevention program (once a week for 30-45 minutes) were analysed. The main outcomes measures included: Nordic Questionnaire [3] to evaluate pain, and Questionnaire of Slesina [4] to judge physical strains. The analysis incorporated Chi2-tests (SPSS 23; Armonk, New York).

**RESULTS:**

The intervention reduced the perceived strains of the participating nurses in the areas of heavy physical tasks (Chi2= 76.537; p< 0,001; C= 0.599), awkward postures (Chi2= 65.089; p< 0,001; C= 0.566) as well as holding (Chi2= 71.422; p< 0,001; C= 0.584), carrying (Chi2= 88.807; p< 0,001; C= 0.629) and lifting (Chi2= 76.755; p< 0,001; C= 0.629) heavy load. In addition, the pain in the lumbar spine (Chi2= 60.003; p< 0,001; C= 0.523), thoracic spine (Chi2= 58.159; p< 0,001; C= 0.534) knees (Chi2= 50.608; p< 0,001; C= 0.509) and feet (Chi2= 81.828; p< 0,001; C= 0.598) were reduced, whereas the pain in the neck increased (Chi2= 44.055; p< 0,001; C= 0.462).

**CONCLUSION:**

Even the small amount of training was suitable to reduce the perceived physical strains and musculoskeletal pain in elderly care nurses. Only the neck pain could not be reduced. Future research, could integrate a longer intervention period which could have an additional positive effect on neck pain. Furthermore, the question of how the non-participating nurses can be motivated to participate should be addressed.

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**CP-MH17 Medicine and health: Mixed****SAMU-DISFIT: A FEASIBLE AND RELIABLE FITNESS BATTERY FOR PEOPLE WITH DOWN SYNDROME**

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**INTRODUCTION:**

In most studies with people with ID, the tests used to assess Physical Fitness (PF) were tests designed for non-disabled people without assessing the conditions for their repeatability and viability in people with DS [1, 2, 3, 4]. Therefore, the main aim of this study was to assess the psychometric properties of a new fitness battery to measure PF of DS people: the SAMU DIS-FIT battery.

**METHODS:**

Eight field-based tests to assess the PF of adults with DS were included: Body Mass Index (BMI), Waist Circumference (WC), the Timed Up and Go test (TUG), the Deep Trunk Flexibility test (DTF), the Hand Grip test (HG), the Timed Stand Test (TST), the 30-s Sit-Up (SUP) and the 6-Min Walk Test (6MWT). In order to adapt the battery to the physical and cognitive characteristics of individuals with DS some non significant adaptations were made. After that, a cross-sectional study with a test-retest design was performed in a maximum interval of 2 weeks in order to assess the following psychometric properties of the battery: reliability and feasibility. 37 subjects with DS (11 women and 26 men) aged between 21 and 58 years old participated in the study. A mixed factorial ANOVA was performed with test-retest measurements to find possible differences between the groups (men and women) and between the conditions (test-retest). The feasibility ending rates were calculated as following: <50% not feasible, 50–75% quite feasible and >75% feasible. The reliability of the SAMU-DIS FIT test-retest was determined by the intra-class correlation coefficient (ICC).

**RESULTS:**

Except for the 6MWT, whose reliability was fair, the ICC in all tests was good and high (>0.80). All the feasibility results were excellent (>97%), except for the SUP (82.45%).

**CONCLUSION:**

SAMU DIS-FIT battery is reliable and feasible for people with DS. Being the first step of our project, it will serve in future research as a tool to establish reference values of PF levels in people with DS and, thus, enable carrying out intervention programs of physical activity and health adapted to the characteristics of these individuals.

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**THERMOGRAPHIC PROFILE OF DELAYED-ONSET MUSCLE SORENESS (DOMS) INDUCED BY ECCENTRIC RESISTANCE TRAINING: PRELIMINARY RESULTS.**

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**INTRODUCTION:**

Eccentric exercise usually causes muscle damage and delayed pain usually defined as "delayed onset muscle soreness" (DOMS). IR images (thermograms) detect skin temperature (Tsk) and can be a valid technique to detect DOMS, especially within the first 24 hours of exercising (Formenti et al. 2016, Al-Nakhli et al. 2012). The present study aimed to evaluate the thermographic data in young male athletes suffering from DOMS induced by a 1-hour session of plyometric exercises.

**METHODS:**

18 Young male athletes participated in this study (age: 24.1 ± 4.2 years, height: 1.78 ± 0.07 m, body-mass: 76.33 ± 11.57 kg, body mass index: 23.99 ± 2.27 kg·m<sup>-2</sup>). All participants realized a 1-hour session of plyometric eccentric exercises. To study the changes in skin temperature of the participants, two thermal images of the lower limb were recorded with a FLIR T335 thermal camera (FLIR Systems®, Dan-

deryd, Sweden), before (T1) and after the eccentric session (T2), and 24h (T3), 48h (T4) and 72h (T5) after the session. Infrared thermography data collection was measured following the recommendations of the TISEM consensus guidelines (Moreira et al. 2017). All the registered thermograms of each subject were analyzed by the software Thermohuman® (Thermohuman, Madrid). Evolution of the Tsk was analyzed by a one-way ANOVA of repeated measures.

**RESULTS:**

In the posterior part of the lower limbs (i.e. Thigh, popliteal fossa and leg), the eccentric exercise session caused a significant decrease ( $p < 0.05$ ) in the temperature (T1 vs T2), and a progressive increase at 24h, 48h and 72h (T2 vs T3-T4-T5,  $p < 0.05$ ), reaching a recovery of the initial Tsk after 24h (T1 vs T3-T4-T5,  $p > 0.05$ ). In the anterior part (i.e. Thigh, knee and leg), we observed the same Tsk compartment, but it was only significant at the leg ( $p < 0.05$ ).

**CONCLUSION:**

The eccentric resistance training session produces an immediate decrease of Tsk and a subsequent rise between 24-72h. The initial Tsk levels are recovered and even slightly but not significantly elevated 24h after the training session. These results agree with the literature (Formenti et al. 2016, Al-Nakhli et al. 2012). Thermography could be a good control tool of the muscle recovery of the subject after strenuous exercise.

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**TEST-RETEST RELIABILITY OF THE INTERNATIONAL FITNESS SCALE (IFIS) IN PEOPLE WITH SEVERE MENTAL ILLNESS. THE PSYCHIATRIC PROJECT.**

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UNIVERSIDAD PABLO DE OLAVIDE

**INTRODUCTION:**

Severe mental illness (SMI) is a leading cause of disability and mortality worldwide. This population has an unhealthy lifestyle, contributing to an accelerated deterioration of fitness, and consequently, an increased risk of death from any cause [1]. The self-reported questionnaire "International Fitness Scale" (IFIS) [2] is a simple and effective tool, validated in healthy and clinical populations that allows to estimate the fitness. The objective of this study was to analyse the reliability of the IFIS questionnaire and its components in people with SMI.

**METHODS:**

In total, 174 adults (♂ = 49, 18-65 years) with SMI completed the IFIS questionnaire twice, with an interval of 2 weeks. The IFIS consists of 5 items to assess the level of fitness and its components (cardiorespiratory fitness, strength, speed and agility and flexibility) using a Likert scale (from very poor = 1 to very good = 5). The agreement between the answers was studied using the weighted kappa coefficients and 95% confidence intervals. In addition, the percentage of perfect agreement (same test-retest answer) and perfect-acceptable (same answer  $\pm 1$ ) for all items in the questionnaire was calculated.

**RESULTS:**

The test-retest agreement of the 5 IFIS items was fair, ranging weighted kappa coefficient from 0.26 (cardiorespiratory fitness) to 0.32 (muscular strength). A 47.2% perfect agreement was observed, as well as a 87.9% perfect-acceptable agreement in the sample. The percentage of agreement between the answers improved by 40.7% when the very poor response was combined with poor and good with very good.

**CONCLUSION:**

IFIS has a fair test-retest reliability for adults with SMI. Combining the extreme categories (poor with very poor and good with very good) improves the level of reliability and stability of the measure. These results support the use of the IFIS questionnaire for the evaluation of fitness in people with SMI.

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**CP-MH18 Exercise therapy**

**ANALYSIS OF EMOTION REGULATION EFFECT BY HOME EXERCISE: A CASE STUDY ON HOME QUARANTINE DURING COVID-19**

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**INTRODUCTION:**

In recent years, the regulating effect of exercise on mental health and emotion has been a hot research topic. The COVID-19 pandemic poses a strong threat to human society in terms of health, economy and lifestyle. To prevent the spread of COVID-19, public health advice (i.e., home quarantine orders, closure of parks, gyms and fitness centres) is likely to reduce daily physical activity. As the epidemic progresses, the greater challenge for sports and mental health is the "second wave" of strikes caused by the COVID-19. People uses social media to express various types of emotions at a historic and unprecedented scale. How to effectively regulate the emotions of the public is very important for epidemic prevention and control. Therefore, the purpose of the study was to explore the effect of emotion changes with home exercise in terms of intensity, time, consumption and manners, for people in home quarantine caused by COVID-19 pneumonia.

**METHODS:**

We collected and cleaned 210,000 Weibo contents with topics of "home quarantine" and "COVID-19" during the closure of Wuhan (from January 23, 2020 to April 8, 2020). 1000 Weibo posts were randomly selected for emotional recognition based on the technology of natural



language processing (NLP). Furthermore, a questionnaire with 22 questions was designed to survey the effect of emotion changes with home exercises. 485 subjects were organized to exercise at home for a week and then answered the questionnaire online. The obtained data was analyzed using SPSS tool. Quantitative analysis contains: 1) the distribution of subjects psychological state and stress level; 2) the distribution of subjects exercise intensity, time and consumption. Qualitative analysis contains: 1) the subjective cognition on the effect of different home exercises; 2) the effect of intelligent exercise for subjective feeling.

**RESULTS:**

According to psychological classification of emotions, 272 Weibo posts reflect the following basic emotions: joy (76), sadness (48), fear (103), disgust (8) and surprise (37). It indicates that more than half of the samples showed negative emotions affected by COVID-19 pneumonia. 445 subjects have finished the experiment and questionnaire, among whom the number of young adults (18-40 years old) accounted for 87.86%. The Cronbachs alpha and validity factor of the questionnaire survey is 0.752 and 0.735 respectively, and the analysis results show that different home exercise have different effects on subjective emotions. Exercises of medium-high intensity, 30-50 minutes, and medium consumption, have the best regulation effect for negative emotions during home quarantine, and intelligent exercises also have benefit to emotion regulation and stress management.

**CONCLUSION:**

The mood of public has been negatively affected in home quarantine caused by the COVID-19 pneumonia. Appropriate physical exercise can effectively relieve peoples emotional problems, and home exercises about 30 minutes with moderate intensity have the best performance. Besides, intelligent exercise is an effective exercise manner to regulate emotions since it can cover some shortages of home exercise (i.e., social demand and exercise guidance).

**THE EFFECT OF POST-EXERCISE APPLICATION OF FULL BODY COMPRESSION GARMENT IN DELAYED ONSET MUSCLE SORENESS AFTER 107 KM TRAIL RUNNING.**

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**INTRODUCTION:**

Ultra trail running is increasing in number of runners. Activities with a higher contribution of eccentric muscle contraction in long distances result in extensive muscle damage (1). It has been reported that compression garments (CG) may enhance recovery by reducing the space available for swelling, resulting in lower pain perception (2).

Moreover, although it has been observed that CG reduce delayed onset muscle soreness (DOMS) (3), most of this research has been done by laboratory tests, and more research in field is necessary. The objective of the study was to analyse the influence of wearing full body compressive garment (t-shirt and leggings) (FBCG) during 24h after trail running competition on DOMS.

**METHODS:**

32 runners participated in the study (19 men(m) and 13 women(w); age; m:41±5, w:41 ±6years; body mass index: m:23.7±1.6 kg/m<sup>2</sup>, w:21.9±2.1 kg/m<sup>2</sup>)training volume: m:9.7 ±3.3, w: 8.9 ±4.4 h/week). Participants were randomized in two different recovery groups: 1) wearing FBCG during 24 hours after competition, and 2) control (without compressive garment). Competition was the 2019 Penyagolosa Trails with a distance of 107 km, 5600 m of positive slope and 4400m of negative slope. The composition of FBCG was 88% polyamide and 12% elastane, its weight was 345g, and it had a graduated compression of 10-15 mmHg, according to the manufacturer's specifications and validated in the Textile Research Institute (AITEX) with the MST MK IV (Salzmann Group, Switzerland) compression measurement device. DOMS was evaluated before, immediately after and 24h after the trail with a visual analogue scale, ranged from to the most uncomfortable at all (0 cm) to the most comfortable condition imaginable (10 cm) at different body regions.

Repeated-measures ANOVAs with the three measurement moments as intra-subject factor and the two group conditions as inter-subject factors were performed for each region. Cohen's effect size (ES) of significant pair comparisons was estimated.

**RESULTS:**

Similar DOMS was observed for both conditions at trunk and thigh regions and at the different measurement moments (p>0.05). However, runners who wore FBCG presented 24h post trial competition lower DOMS than controls at anterior knee and leg (1.8±1.2 vs. 3.4±2.3 cm; p=0.01 and ES=1.0) and at posterior knee and leg (2.1±1.3 vs. 4.1±2.2 cm; p<0.01 and ES=1.1).

**CONCLUSION:**

It was observed that runners who used FBCG during first 24 hours post-race (107km) showed lower values on the perception of muscle damage in the regions knee and leg (anterior and posterior). Similar results were found using CG during uphill running experiment (4) and using CG after a marathon (5).

The use of FBCG could be suggested as an effective strategy to improve the perception of recovery.

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**EFFECTS OF ACUTE HUMAN TECAR® INTERVENTION DURING POST-EXERCISE RECOVERY ON HIGH-INTENSITY INTERVAL TRAINING PERFORMANCE AND SLEEP QUALITY.**

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INSEP

**INTRODUCTION:**

Post-exercise recovery interventions affected subsequent daily performance. Studies about environmental modifications during post-exercise recovery generally focused on the effects of cold exposure on performance reiteration. However, maintaining a muscular temperature around 38°C after exercise increased aerobic performance due to the effects of local heat on contractile function and muscle glycogen resynthesis [1]. Our objective was to observe the effects of local muscle endothermia on the repeated sprints ability (RSA) and the sleep quality.

**METHODS:**

10 moderately trained subjects (25.0±4.1 years, BMI: 23.2±3.6) performed, after familiarization and one week apart, two sessions of 2 sets of 6 sprints (RSA: 6 × 10-s, intercepted by 30-s of passive recovery) on a cycle ergometer (Pro/Trainer, Wattbike, Nottingham, UK). Before and after each set, the peak torque of knee extensors (PT) was evaluated on an isokinetic dynamometer (System 3, Biodex Medical Systems, USA). For each session, both RSA sets were intercepted by 24 hours (D and D+1), during which time, in randomized order, subjects were exposed to local muscle endothermia (HCR 1002, Human Tecar®, Unibell srl, Italy) or placebo (PL) during 30 minutes post-RSA. Maximal (Pmax) and mean power output (Pmean), rate of perceived exertion (RPE) and muscle pain (VAS 1-10) values were measured during and after each sprint. Sleep quality (Spiegel's questionnaire) was assessed at the awakening, in the morning of each set.

**RESULTS:**

No significant PT, Pmean and Pmax values were found between D and D+1 in both post-exercise recovery conditions. Whereas a lower decrease in Pmean between the first and second sprints repetitions after HCR 1002 compared to PL interventions (1.2±9.9 vs. 4.5±6.0 %, p=ns), RSA ability, RPE and subjective muscle pain values were not affected by post-exercise recovery intervention. Spiegel's questionnaire score improved after HCR 1002 compared to baseline (23±1 vs. 20.1±1.2, p<0.05). No significant difference in Spiegel's score was found between baseline and PL (20.1±1.2 vs. 21.5±1.4, p=ns).

**CONCLUSION:**

The local muscle endothermia induced by the HCR 1002 system did not delay fatigue during RSA performed at 24-hour interval. In contrast to the literature [2], HCR 1002 system did not have a significant effect on 24-h post-exercise value of mechanical power (Pmax, Pmean). However, 30-min of HCR 1002 improved the quality of sleep following a high-intensity interval training trial. Further studies are needed to explain our findings and investigate the effects of HCR 1002 as a regular post-exercise recovery strategy on athletic performance.

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## CP-PN01 Pregnancy / Menstruation / Fertility

### THE RELATIONSHIP BETWEEN ABDOMINAL MUSCLE THICKNESS AND PREGNANCY-RELATED LOW BACK PAIN.

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**INTRODUCTION:**

More than 50% pregnant women experience low back and posterior pelvic pain during pregnancy (PLBP), and 45% of these women continue to express these pains in postpartum. Therefore, PLBP impaired quality of life and activities of daily living during pregnancy and postpartum. The etiology of PLBP remains unknown. Although the association between the thickness of abdominal muscle and low back pain in general population has been well studied, it is not clear during pregnancy. This study was performed to examine the relationship between low back pain and abdominal muscle thickness during pregnancy. Understanding this relationship help develop effective exercise during pregnancy.

**METHODS:**

In this study, 49 pregnant women (31.8 ±4.2 years old) in second trimester pregnancy who attended the obstetrics and gynecology clinic were participated. Those with low back disorders, such as hernias, were excluded. The intensity of PLBP was assessed using the Numerical Rating Scale (NRS). B-mode ultrasound imaging was used to measure abdominal muscle thickness; the rectus abdominis (RA), external oblique (EO), internal oblique (IO), and transversus abdominis muscle (TrA). Depending on the presence or absence of PLBP, participants were classified to two groups; a group with PLBP (Pain group), a group without PLBP (no-Pain group). Unpaired 2-tailed t-test or Mann-Whitney U test were used to compare abdominal muscles thickness respectively among two groups. Thereafter, when a significant difference was observed, we used a multivariate logistic regression analysis, with adjustment for age and BMI. The statistical significance level was set at p<0.05.

**RESULTS:**

There were 24 participants in pain group and 25 subjects in no pain group. IO muscle thickness (p=0.042) was significantly lower in Pain group (5.4±0.2 mm) than no-Pain group (6.1±0.2 mm). No significant differences were observed in the remaining 3 muscles. The multivariate logistic regression analysis showed that IO muscle thickness was significantly associated with PLBP (odds ratio [OR], 0.496; 95% confidence interval [CI], 0.270-0.914; p=0.014).

**CONCLUSION:**

This study suggested that PLBP in second trimester pregnancy may be related to IO muscle thickness. Previous studies have shown that IO muscle can help prevent poor postures such as sway back posture and contribute to maintaining good posture. It has also been suggested that IO muscle may defuse the shear loading on the sacroiliac joint against pelvic ligament relaxation and play a role of the pelvic belt. Thus, there is a possibility that IO muscle may contribute to the stability of the lumbar spine and the pelvis. The findings of this research show that maintaining IO muscle thickness during pregnancy may affect the incidence and relief of PLBP. Therefore, maintaining the muscle thickness and strength of IO may lead to future effective exercise approaches to prevent and treat PLBP. This study could also help female athletes return to competition after childbirth.

### HEART RATE AS A METHOD OF INDIVIDUAL CONTROLLING AND ADJUSTING A SAFE PHYSICAL LOAD DURING ORIGINAL PROGRAM OF WATER AEROBICS FOR PREGNANT WOMEN

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**INTRODUCTION:**

A large number of scientific papers are devoted to assessing the effect of water aerobics on a pregnant woman and fetus; however, the content of classes and dosing of the load is still the subject of active research and discussion.

**METHODS:**

The objective of our study was to optimize the load intensity, namely, to increase the efficiency and to minimize the uncontrolled loads, during water aerobics classes for healthy women with uncomplicated pregnancies, as well as to determine the optimal and individual limits of the heart rate target zone (THR) at different stages of the training cycle, with strict and compulsive medical and pedagogical control of the physical, functional and mental state of those involved and constant self-monitoring of their sense of well-being. In a six-year study with informed consent, 785 pregnant women took part (singleton gestation, gestational age 15—40 weeks).

**RESULTS:**

Using the originally developed method of conducting water aerobics classes and an innovative approach to determining resting heart rate, it was possible to calculate the optimal dose of workload and to determine an individual THR for each practically healthy pregnant woman without a pronounced pathology and to get positive results. Timely preventive measures in the form of regular water aerobics classes, starting from the second trimester of pregnancy and accompanied by strict monitoring of pregnant women's well-being and individual dosing of physical activity by a heart rate at different stages of training, significantly reduce the frequency of such pregnancy complications as preeclampsia and contribute to the natural delivery of a healthy baby. Such prevention is especially relevant in order to reduce potential complications for the mother and fetus/child, especially when the pregnant woman has the preconditions for preeclampsia (edema, and/or arterial hypertension, and/or proteinuria).

**CONCLUSION:**

Application of the originally developed method of water aerobics classes, accompanied by compulsive and constant monitoring of the health status and well-being of those involved, allows specialists to develop an individual plan of training sessions, as well as increases significantly the effectiveness and safety of currently used water-based wellness procedures.

The results were presented as a patent application no. 2019112754 dated June 13, 2019 ("A method for the preeclampsia prevention for pregnant women by means of water aerobics").

The study was supported by Sports and Education Company "Genius-Sport", LLC, St. Petersburg, Russia.

**CROSS-SECTIONAL ANALYSIS OF THE ASSOCIATIONS OF 24-HOURS ACTIVITY COMPOSITION WITH CARDIORESPIRATORY FITNESS AND ADIPOSITY THROUGHOUT PREGNANCY: THE PREGNACTIVE PROJECT.**

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**INTRODUCTION:**

Physical activities have potential benefits to reduce the risk of adverse cardiovascular health outcomes during pregnancy [1]. Lifestyle activity behaviors are mutually exclusive components of the 24-h day and, to properly understand their association with health, they should be studied relative to each other rather than in isolation. Compositional data analysis is a novel approach that considers activity behaviors as exclusive and exhaustive parts of whole 24-hours [2]. This study aimed to examine the cross-sectional associations between 24-hours activity composition (sleep, sedentary time, light and moderate-to-vigorous physical activity) with adiposity and cardiorespiratory fitness (CRF), and how isothermally reallocated time between activity behaviors are associated with predicted differences in adiposity and CRF throughout pregnancy.

**METHODS:**

A cross-sectional study was conducted among 220 healthy pregnant women at midpregnancy (n=130) and later pregnancy (n=90). Activity behaviors were objectively assessed by multi-sensor monitors. Adiposity was assessed by skinfold thickness. CRF was assessed using a 6-minute walk test. Statistical analysis included log-ratio multiple linear regression models and compositional isothermally substitutions.

**RESULTS:**

The activity composition was associated with adiposity ( $p < 0.001$ ) and cardiorespiratory fitness ( $p < 0.001$ ) both at midpregnancy and later pregnancy.

The isothermally substitutions showed the highest estimated difference in predicted adiposity (6.0%, 2.6 mm of the sum of skinfold thickness) at midpregnancy when 30-minutes of moderate-to-vigorous physical activity (MVPA) was reallocated by sedentary time (ST). However, at later pregnancy the highest estimated difference in predicted adiposity (5.4%, 2.3 mm of the sum of skinfold thickness) was found when light physical activity (LPA) was reallocated by ST. The highest estimated difference in predicted CRF was found when 30-minutes of MVPA was reallocated by ST, both at midpregnancy (-4.1%, -1.4 mL/kg-min) and later pregnancy (-4.7%, -1.5 mL/kg-min).

**CONCLUSION:**

The activity composition was associated with adiposity and CRF, with MVPA being the leading behavior for CRF at both points of pregnancy, and for adiposity at midpregnancy, while LPA was the leading behavior for adiposity at later pregnancy.

Our findings reinforce the key role of physical activity for health throughout pregnancy. To reallocate ST to MVPA and LPA is advocated to develop lifestyle interventions for pregnant women.

**References:**

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**COMBINED INDICATORS OF BASAL BODY TEMPERATURE INTERPRETATION WITH 2 QUANTITATIVE METHODS CAN ACCURATELY DETECT ANOVULATORY & SUB-OPTIMAL PEAK SERUM PROGESTERONE IN ATHLETES' MENSTRUAL CYCLES**

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**INTRODUCTION:**

The use of basal body temperature (BBT) interpretation to indicate normal ovulatory or ovulatory disturbed (<10-day post-ovulatory (high-BBT) phase [1]) menstrual cycles (MC) requires further validation. MC with adequate progesterone imply fertility, wellness and osteoporosis prevention. Thus, accuracy of BBT quantitative interpretation to indicate ovulatory status (OS) of MC was examined.

**METHODS:**

20 race walkers and runners (14 – 41 years, training 20 – 109 km·week<sup>-1</sup>) documented sublingual BBT (digital thermometer) & confounders (insomnia, illness, alcohol ingestion, unusual environment or sleep/wake time) daily in 1 – 2 MC. Day of peak luteinizing hormone (LH) was identified in urine (hLH Cassette 002L040 UltiMed™; detecting 30 mIU·mL<sup>-1</sup>). Peak-serum progesterone concentration (Pk-PRG) was determined 6 – 9 days after LH peak, but at least 3 days before onset of next MC [2] (electrochemiluminescence immunoassay; Cobas e601). BBT graphs of MC were interpreted with Quantitative Basal Temperature (QBT) method and Sensiplan® rules.

**RESULTS:**

OS of 26 MC was confirmed by Pk-PRG. No relationship was found between luteal phase length (LPL) and Pk-PRG. Besides no or late ovulation, ovulation at expected timing (LPL >10 days) with sub-optimal Pk-PRG (<10 ng·mL<sup>-1</sup>) was observed. QBT-defined high-BBT phase length correlated with Pk-PRG ( $r(20) = .65$ ;  $p < 0.001$ ;  $1 - \beta = .987$ ) only if: i) corrected to begin after BBT drops to/under mean-BBT line in the first few days after BBT shift from under to over this line & ii) ignoring BBT drops in the last 2 days. MC with QBT-defined high-BBT phase of >10 days had optimal Pk-PRG, and if BBT remained over the mean until the end, above 16 ng·mL<sup>-1</sup>. QBT and Sensiplan® rules identified ovulatory Pk-PRG (>5.8 ng·mL<sup>-1</sup>) similarly (67% vs. 75% specificity). QBT recognized sub-optimal Pk-PRG better than Sensiplan® (94% vs. 67% sensitivity). No method was accurate enough (67 – 84%) to indicate OS by Pk-PRG. However, indicators derived from QBT-&-Sensiplan®-combined BBT interpretation discriminated between MC with anovulatory & ovulatory and sub-optimal & optimal Pk-PRG with an accuracy of 100% and 92%, respectively.

**CONCLUSION:**

In physically active females, not using hormonal contraception, interpreting a carefully documented BBT graph of a MC with both QBT & Sensiplan® appears to be a useful non-invasive screening tool to accurately assess OS and thus could help in monitoring the effect of energy restriction and/or increased exercise volume.

**References:**

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**EFFECTS OF MENSTRUAL CYCLE ON OXIDATIVE STRESS AND ANTIOXIDANT RESPONSE TO HIGH-INTENSITY INTERMITTENT EXERCISE UNTIL EXHAUSTION IN EUMENORRHEIC WOMEN**

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**INTRODUCTION:**

Ovarian hormones (estrogen and progesterone) have antioxidant effects. Premenopausal women experience changes in blood concentrations of estrogen and progesterone throughout the menstrual cycle. Levels of estrogen and progesterone are lower during the early follicular phase (FP) and higher during the luteal phase (LP). Several studies have reported that oxidative stress changes with the menstrual cycle during endurance exercise. However, the effects of high-intensity intermittent exercise until exhaustion during exercise and recovery remain unclear. This study aimed to investigate effects of the menstrual cycle on oxidative stress and antioxidant response during high-intensity intermittent exercise until exhaustion in eumenorrhic women.

**METHODS:**

Subjects comprised 10 eumenorrhic women (mean (± standard deviation) age, 20.1±1.3 years; height, 160.7±4.6 cm; weight, 56.4±6.4 kg; body fat, 24.0±3.5%), who were engaged in habitual, recreational exercise (aerobic exercise <120 min/time; 2-3 times/week). Subjects performed high-intensity exercise until exhaustion on a cycle ergometer during FP and LP. Blood samples were collected before exercise (Pre), immediately after exercise (Post0), and 60 min after completion of exercise (Post60). Levels of estradiol, progesterone, oxidative stress (diacron reactive oxygen metabolites: d-ROMs), and antioxidant capacity (biological antioxidant potential: BAP) were assessed. Durations of each phase of the menstrual cycle were estimated by assessing levels of estradiol and progesterone. Antioxidative/oxidative stress ratio was also calculated as BAP/d-ROMs.

**RESULTS:**

Mean duration of the menstrual cycle was 29.2±4.2 days. In addition, FP was 5.3±1.7 days and LP was 23.1±2.1 days. Levels of serum estradiol (FP, 33.7±16.3 pg/mL; LP, 184.5±58.5 pg/mL;  $p < 0.001$ ) and progesterone (FP, 0.2±0.2 ng/mL; LP, 12.4±5.7 ng/mL;  $p < 0.001$ ) were significantly higher in LP than in FP at Pre. The values of d-ROMs, BAP, and BAP/d-ROMs were not significantly affected by menstrual cycle phase at Pre, Post0, or Post60 (d-ROMs,  $p = 0.55$ ; BAP,  $p = 0.85$ ; BAP/d-ROMs,  $p = 0.94$ ). However, rates of change of d-ROMs from Pre were significantly lower in LP than in FP of the menstrual cycle at Post0 and Post60 ( $p < 0.05$ ). The rate of change of d-BAP from Pre was not significantly affected by menstrual cycle phase at Post0 or Post60 ( $p = 0.734$ ). Rate of change of BAP/d-ROMs from Pre tended to be higher in LP than in FP at Post0 and Post60 ( $p = 0.058$ ).

**CONCLUSION:**

Our results suggest that LP, when estradiol and progesterone levels are higher than in FP, may eliminate oxidative stress during high-intensity intermittent exercise until exhaustion in eumenorrhic women.

**CP-PN02 Female triad / Energy restriction / Anorexia**

**DESIRE FOR THINNESS AND SUCCESS - THE CASE OF A FEMALE CYCLIST**

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**INTRODUCTION:**

Cycling is considered a high-risk sport for the development of disordered eating (DE) and eating disorders (ED). Therefore, it is not surprising that unhealthy eating behaviors are a frequent problem in female cyclists. A 19-year-old female semi-professional cyclist (49 kg, 165 cm) presented herself, reporting fatigue in training, poor recovery and sleep disturbances. Despite these problems the athlete tried to

complete the training program and perform the typical weekly training loads but stated she had finished most of her recent workouts feeling really empty.

**METHODS:**

After an initial contact, a nutritional assessment was conducted to obtain comprehensive information on the athlete's nutrition and medical history. The cyclist's dietary intake was assessed through a food frequency questionnaire and a 5-day food diary. Data of the latter were analyzed for total energy, macro- and micronutrient content. In order to identify any possible nutrient deficiencies and hormonal and metabolic imbalances a blood test was suggested.

**RESULTS:**

The interview revealed that the cyclists had lost 8 kg within a 5-month period. The athlete reported she had reached her highest weight (wt; 57 kg) after an injury and wanted to lose the excessive wt to get back into shape for the new season. She limited her diet to mostly vegetables and protein (PRO), and avoided fat, carbohydrates (CHO) and sweets. The only CHO she included into her diet were oats for breakfast and legumes with salads, yet the portions were insufficient. On race days she added some extra CHO into her pre-race meal. She kept snacking to a minimum (0-1 snacks/d). Most trainings were done with water or electrolyte solutions, on very long rides she added a banana or cookie. The dietary analysis revealed an average intake of 1368 kcal/d (3.3 g CHO/kg/d, 1.7 g PRO/kg/d, 0.8 g fat/kg/d).

She has never had a regular menstrual cycle and has not had any menstrual cycle for the last 4 months, i.e. since she reduced her intake and started to lose wt. The cyclist further mentioned she has had sleep disturbances and woke up at least twice every night since changing the diet.

The blood test revealed normal values except for cortisol and thyroid hormone (T3). Although her diet did not include any of the main iron (Fe) sources, her Fe levels were normal. This can be explained by daily Fe supplementation she started when she was once diagnosed with low Fe.

**CONCLUSION:**

This case confirms the high risk of cyclists for developing unhealthy eating behaviors in order to lose wt. The combination of wt gain after injury and the goal to reduce body wt and body fat for better cycling performance can become a dangerous trigger. Performance and medical staff should be aware of the risk, signs and symptoms of ED and ED, and be even more alert in situations of injury or sickness, i.e. in times when athletes are not able to train and wt gain is likely.

**THE ROLE OF THE RENIN-ANGIOTENSIN SIGNALLING PATHWAY IN MUSCLE MASS PRESERVATION DURING A SEVERE ENERGY DEFICIT IN HUMANS**

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**INTRODUCTION:**

Angiotensin I is converted to Angiotensin II (ANGII) by the angiotensin-converting enzymes ACE1 and ACE2. ANGII upregulates the MAPK and ERK1/2 signalling pathways through the angiotensin type I receptor (AT1R). This activates NADPH oxidase and promotes production of ROS, eliciting skeletal muscle (SM) catabolism. Here we study the regulation of SM renin-angiotensin system (RAS) signalling during a severe energy deficit. We hypothesized that exercise may counteract RAS activation in SM during energy deficit, thereby sparing SM mass.

**METHODS:**

Fifteen overweight men underwent 4 days of caloric restriction (CR) (0.8 g/kg BW/day of either whey n=8 or sucrose n=7) and prolonged exercise (PE) (45min of one-arm cranking and 8h walking/day). Muscle biopsies from both deltoid and one vastus lateralis were taken before (PRE), after CR+PE and following 3 days of control diet (isoenergetic) and reduced exercise (CD). Plasma renin and aldosterone were measured. ACE1, ACE2, AT1R, and AT2R protein expression were analysed (Western Blot). Body composition was assessed by DEXA. Statistics: Repeated-measures ANOVA.

**RESULTS:**

After CR+PE, the energy deficit was 5500 kcal/d, reducing fat-free mass (FFM) (P<0.001). Legs and trained arm lost proportionally less FFM than the untrained arm [57% (P<0.05) and 29% (P=0.05), respectively]. Plasma aldosterone and renin significantly increased after CR+PE, and to a greater extent in the whey protein group (interaction, P<0.05). The basal expression of ACE1 and ACE2 was higher in arms than legs (P<0.001). ACE1 and ACE2 expression were increased from PRE to CR+PE and even further from PRE to CD. ACE2 (mean of both arms) was similarly increased in both groups from PRE to CR+PE and PRE to CD, but this response was blunted in the legs (interaction P=0.035). AT1R was more expressed in legs than arms (P<0.05) and did not change with the intervention. AT2R was similarly reduced in all muscles from PRE to CR+PE (P=0.04), remaining lowered after CD.

**CONCLUSION:**

During severe energy deficit, RAS signalling is upregulated in human arm muscles via markedly increased expression of ACE1 and ACE2. This was accompanied by a proportionally higher loss of muscle mass in the arm than the legs. In turn, in the legs, there was no-upregulation of ACE2. Some studies have shown that angiotensin receptor blockers may attenuate SM atrophy due to disuse and facilitate muscle regeneration after orthopaedic trauma. The fact that the subjects who ingested only whey protein lost more SM mass (1) and displayed more activation of circulating RAS also points in this direction. Altogether, this study indicates that a high volume of exercise, like that performed by the legs blunt the local upregulation of RAS, what could explain the sparing effect of exercise on lean mass. New studies should determine whether pharmacological inhibition of RAS may help to spare muscle mass during severe energy deficit.

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**TIME RESTRICTED EATING - RISK OR BENEFIT? THE CASE OF A MALE COMBAT SPORTS ATHLETE**

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**INTRODUCTION:**

Athletes choose numerous strategies to manage and reduce their body weight (BW) and body composition. The commonly suggested approach requires continuous energy restriction. More recent new approaches such as intermittent fasting or time restricted eating (TRE) have become popular among athletes. While BW loss may be the goal, extreme BW loss strategies can lead to losses of fat free mass (FFM), and furthermore compromise health and performance. A 28-year-old male combat sports athlete (karate; 72 kg, 176 cm) reported perfor-

mance and weight concerns. The athlete complained about a lack of energy, sleep disturbances, head ache, increase in BW, BW fluctuations +/- 3 kg and fluid retention, gastrointestinal issues (e.g. bloating).

**METHODS:**

A nutritional assessment was done, including a food frequency questionnaire, questions on diet and BW history. Furthermore, a blood test was requested to assess the hormonal and metabolic profile of the athlete.

**RESULTS:**

The results of the blood test revealed normal values except for elevated creatine kinase (CK) and liver enzymes (aspartate aminotransferase (AST), alanine aminotransferase (ALT)). All other markers were within normal limits.

The athlete had changed his diet for the final part of the season in order to lose BW. Having heard of TRE, he chose the 16/8 approach and had breakfast at 7.30 am and stopped eating at 3.30 pm respectively. This BW loss approach, however, required to do workouts later in the day without energy intake (karate). Since he went to bed after the evening workouts, he firstly felt ok doing the workouts without additional energy intake and had a big breakfast the next morning. After an initial successful BW loss, his BW started to increase and he noticed symptoms like poor sleep, lack of motivation and energy. His meals consisted of mostly complex carbohydrates with big protein servings, as he wanted to increase satiety and preserve his FFM through higher protein intake.

**CONCLUSION:**

This case shows that athletes are open to drastic BW loss strategies to become successful and reach a target BW. Although some BW loss strategies seem promising in managing metabolic disorders, they are not appropriate for high level athletes who have different nutrient and energy requirements. Low energy availability and insufficient energy intake increase the stress on the athlete's body and immune system, ultimately leading to health and performance issues. After the analysis, the athlete has been consulting a sports dietitian and has been educated on energy needs, nutrient timing and nutrition quality as well as proper weight management.

### LOW ENERGY AVAILABILITY IN SPORTS: WHAT ABOUT WHEELCHAIR ATHLETES?

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**INTRODUCTION:**

Low energy availability (LEA) is a major problem in sports as athletes ingest often a lower amount of energy compared to their actual needs (1). The availability of energy is calculated based on their daily energy intake and the energy cost of the daily training sessions in relation to their fat-free mass. Based on this calculation, it is known how much energy will be available for the body (beside the fuel for training) to keep it in optimal physiological functioning. It has been shown (2), that LEA occurs very often in female athletes, in endurance athletes as well as athletes in weight-sensitive sports (i.e. jockeys, combat sports, gymnastics, ballet). The purpose of this study was to investigate, whether LEA is a problem in wheelchair athletes as well.

**METHODS:**

In 14 wheelchair athletes (8 male, 6 female), energy intake as well as energy expenditure during training were recorded over seven days. In addition, athletes recorded leisure time, physical activity as well as supplement intake. Furthermore, resting energy expenditure (REE) and body composition (DXA) were measured before the start of the study. Based on all recordings, energy availability (EA= (energy intake (EI) – exercise energy expenditure)/fat-free mass) as well as total energy expenditure (TEE) were calculated. EA was categorized into optimal (>45 kcal/kg FFM/d), suboptimal (30-45 kcal/kg FFM/d) and LEA (<30 kcal/kg FFM/d). Energy balance (EB) was calculated from TEE and EI. In addition, it was analyzed whether athletes consumed optimal nutritional fuels before, during and after training session.

**RESULTS:**

The mean value for EA over the 7 days significantly different ( $36.1 \pm 6.7$  kcal/kg FFM/d) in male compared to female ( $25.1 \pm 7.1$  kcal/kg FFM/d) athletes ( $p < 0.001$ ). Those values were categorized as suboptimal (male) and LEA (female). From all athlete days, LEA occurred in 73.3% of the days in female and in 30.4% of the days in male athletes. EB was significantly different between male and female athletes ( $p < 0.001$ ) whereas male athletes showed a positive EB ( $+169.1 \pm 304.5$  kcal) and female athletes a negative EB ( $-288.9 \pm 304.8$  kcal). Concerning the protein guidelines, 70% of male and 39% of female athletes consumed more than 1.2 g/kg/d. After strength or intensive training, 55% of male and 41% of female athletes ingested 20 to 25g of protein. Before training, 63% of male and 71% of female athletes consumed 1 to 4g/kg of carbohydrates.

**CONCLUSION:**

Wheelchair athletes, especially female athletes showed a high occurrence of LEA availability over a seven days period. They might be at a high risk for certain negative health consequences. A higher energy intake would be recommended to meet their energy needs for optimal body functions and maximal adaptation to training stimulus. Further research is needed to elucidate in more detail LEA in wheelchair athletes.

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### RELATIVE ENERGY DEFICIENCY IN SPORT AMONG MALE NORWEGIAN WORLD-CLASS ATHLETES

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**INTRODUCTION:**

The syndrome of Relative Energy Deficiency in Sport (RED-S) is considered an important health issue among female athletes but understudied among male athletes. The aim of this study was to investigate RED-S in Norwegian male world-class leanness (L)- and non-leanness (NL) athletes using objective RED-S related markers.

**METHODS:**

Athletes from L (n=29) and NL (n=15) sports (mean + SD); age  $24.7 \pm 3.8$  yrs, body mass  $81.3 \pm 15.9$  kg, body mass index (BMI)  $24.7 \pm 4.4$  kg/m<sup>2</sup>, fat free mass (FFM)  $70.5 \pm 11.2$  kg, body fat  $13.7 \pm 5.8\%$ , training volume  $76.1 \pm 22.9$  hrs/month were included in the analysis. Besides dividing the athletes into either L or NL sport groups as defined by (1), they were also divided by low- (the lowest quartile of the reference range) and normal testosterone (TES) levels as described by (2). Protocol included assessment of RMR via indirect calorimetry, body composition and bone health by dual-energy X-ray absorptiometry (DXA) and biochemical markers such as TES, free triiodothyronine

(ft3) and Cortisol. Low RMR was defined by values less than 90% of predicted according to the Cunningham equation, and low bone mineral density (BMD) as a Z-score < -1 in either lumbar spine (L1-L4) or femur.

**RESULTS:**

L athletes had lower body mass ( $p<0.01$ ), BMI ( $p<0.001$ ), FFM ( $p<0.02$ ) and body fat% ( $p<0.03$ ) compared to NL athletes. Low lumbar spine BMD was found in 6 L and 1 NL athletes. L athletes had lower lumbar- ( $0.12 \pm 1.43$  vs  $1.49 \pm 1.62$ ,  $p<0.02$ ) and femoral Z-score ( $0.48 \pm 1.08$  vs  $1.73 \pm 1.15$   $p<0.01$ ) compared to NL athletes. Low RMR was evident in 4 L and 3 NL athletes, with no differences between groups ( $p>0.05$ ). Six L and 5 NL athletes had subclinical low TES levels ( $<14$  nmol/L), where one L athlete had clinical low levels ( $<8$  nmol/L). Athletes with low TES were older ( $28.1 \pm 3.7$  vs  $23.8 \pm 3.2$  yrs,  $p<0.01$ ), had lower ft3 levels ( $5.2 \pm 0.7$  vs  $5.7 \pm 0.7$  nmol/L,  $p<0.03$ ) and lower relative RMR ( $27.3 \pm 3.9$  vs  $30.4 \pm 4.0$  kcal/kg FFM/day,  $p<0.05$ ). In addition, more athletes in the low TES group had low RMR (36% vs 10%,  $p<0.05$ ) compared with the normal TES group.

**CONCLUSION:**

Approximately one-sixth of these world class male athletes had low BMD, with the majority among L athletes, although elite athletes in general are expected to have 5-15% higher BMD compared to non-athletes. Furthermore one-quarter of the athletes showed signs of adverse metabolic adaptations, as inferred via biochemical variables and/or RMR, however with no difference between L and NL athletes. In conclusion, in this group of Norwegian male world-class athletes, symptoms of chronic energy conservation related to the syndrome of RED-S were found in both L and NL athletes, indicating that RED-S not only exists among female athletes or in sports emphasizing leanness, and the clustering of these RED-S risk factors warrants further investigation.

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**CP-PN03 Sleep****RELATIONSHIP BETWEEN TRAINING LOAD AND SLEEP QUALITY IN MEDICAL STUDENT ATHLETES**

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**INTRODUCTION:**

Much attention has been given to the relationship between various training factors and young athletic injuries. Athletic performance generally has been shown to be affected by sleep patterns, and sleep deprivation is known to dampen reaction times and affect mood and cognitive functions, which could increase the risk of injury in athletes. However, less literature exists on the specific effects of sleep on training factors, specially in medical student athletes. Objective: To verify the relationship between the training load (time, frequency and participation in competition) with the sleep quality of young medical students athletes.

**METHODS:**

73 young athletes medical student (age:  $21.8 \pm 2.8$  years, height:  $172.8 \pm 9.9$  cm, mass:  $71.3 \pm 13.2$  kg; BMI:  $23.4 \pm 1.7$  kg/cm<sup>2</sup>; medical school time= $2.2 \pm 1.3$  semester 4 to 6) from different sports were evaluated: basketball (n=34), volleyball (n=17), tennis (n=8) and athletics/futsal (n=14). The Pittsburgh Sleep Quality Index Scale-EPsqI (score up to 5 points for good sleep quality, 6-21 points for poor sleep quality) was applied to assess sleep quality. For the training load, a questionnaire was used about the time of sports practice (years), frequency of weekly training (hours) and the number of participation in competitions (2019 year).Pearsons correlation test was used to verify the association between the EPsqI score and training load variables, considering a 5% significance level.

**RESULTS:**

Young athletes who are medical students, showed a moderate and significant correlation between the poor sleep quality ( $10 \pm 4$ ) and the increase in sports practice time ( $6.0 \pm 3.6$ ) ( $r=0.55$ ,  $p=0.001$ ). The frequency of training ( $r=0.12$ ,  $p=0.762$ ) and the number of participation in competition ( $r=0.010$ ,  $p=0.939$ ), did not show any association with poor sleep quality.

**CONCLUSION:**

The literature reveals that poor sleep quality can increase the appearance of injuries in young athletes<sup>1-4</sup>. The differential of this study was to show that young athletes, medical students, showed poor quality of sleep, with a positive correlation with the time of sports practice, showing the importance of the athlete to adjust his sleep with the increase of the years of sports practice for prevent the sport-related musculoskeletal injury.

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**PREVALENCE OF EXCESSIVE DAYTIME SLEEPINESS AND ITS ASSOCIATION WITH DAILY LIFE FACTORS IN JAPANESE FIRST-YEAR UNIVERSITY STUDENTS**

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**INTRODUCTION:**

Recently, as lifestyles have shifted more to night type, sleepiness and sleep-related problems are serious issues to consider in Japan. As reported by Steptoe et al. (2006) [1], Japan, Korea, and Thailand, were notable for having a high proportion of respondents with poor self-rated health as well as short average sleep durations. Excess daytime sleepiness (EDS), an adverse consequence of sleep loss, is considered to be an important public health issue [2]. Since EDS may result in academic difficulties, behavioral abnormalities, and psychological dysfunction, it is an important issue, especially for university students. Therefore, we conducted a cross-sectional study to investigate the prevalence of EDS and associated lifestyle factors among Japanese university students.

**METHODS:**

A questionnaire inquiring about daytime sleepiness, daily life factors, and sleeping habits was answered by 1525 first-year university students aged between 18 and 20 years. The questionnaire covered the following aspects: 1) demographic variables, 2) lifestyle habits, and 3) sleep habits and sleep-related issues. Daytime sleepiness was measured using the Japanese version of the Epworth Sleepiness Scale (JESS) (Takegami et al., 2009) [3], a frequently used subjective sleepiness scale [4]. The JESS score ranges from 0 to 24, with a higher score indicating higher sleepiness. In this study, JESS scores of 11 or more represented increased levels of EDS. Logistic regression analysis was performed to identify lifestyle factors associated with EDS.

**RESULTS:**

The overall prevalence of EDS was 57% (53% for males and 61% for females). In a multivariate logistic regression analysis, the following items were identified as factors associated with EDS: female sex, exercise habits, later wake-up times, and shorter sleep duration.

**CONCLUSION:**

Our data showed that more than half of the first-year university students had EDS. Further studies are required to examine the effects of interventions to extend sleep duration, prevent later wake-up times. As a notable finding was a higher risk of EDS in the students with exercise habits, appropriate measures for those students should be especially considered to prevent adverse consequences of EDS.

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**MONITORING SLEEP DURING ALTITUDE TRAINING CAMPS: AN EFFECTIVE WAY TO OPTIMIZE TRAINING?**

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**INTRODUCTION:**

Altitude training (AT) is a component of modern athletic preparation for endurance sports because it facilitates key physiological adaptations within the athlete improving sea-level performance (1). However, one possible drawback of AT is sleep disturbance (i.e., sleep efficiency) that may result in impairment in training, increased training load (TL) and symptoms of nonfunctional overreaching and underperformance. It is therefore important to understand how training and competition affect sleep but also how sleep may affect performance (3, 4). The aim of the present study was to monitor sleeping parameters in a group of elite endurance athletes during a 14-day AT camp and their effect on subjective training parameters.

**METHODS:**

Five elite open water swimmers (26±2.8 years; 3 females and 2 males) were monitored during a 14-day AT camp at 1800m. One week before AT, athletes were asked to wear on their non-dominant hand an actigraph (Actiwach 2) to evaluate their sleep parameters. They completed a diary to record their bedtime, wake-up time, and their perceived sleep quality. The Philips Actiware 6 Software was used to obtain the following sleep parameters: Total Sleep Time (TST, %), Sleep Latency (SL, min), Sleep Efficiency (SE, %), Movement and Fragmentation Index (MFI) and the Immobility Time (IT, %). For each subject, the data were divided in 4 periods: one week before the AT (PRE), AT 1-2, AT 3-5, and AT 6-8. Moreover, all subjects filled in an online training diary (2). Session RPE (sRPE=RPE\*min) and training volume (TV) were monitored during PRE and AT camp. Data were analyzed by ANOVA for repeated measures and significance set at p<0.05.

**RESULTS:**

SL, SE, MFI and the subjective values of sleep quality significantly worsened from PRE to AT 1-2 (p<0.05) and from PRE to AT 3-5 (p<0.05), specifically SL increased by +14 minutes in AT 1-2 (p<0.05) and SE decreased by -6.0% (p<0.05). On the contrary, TST and IT did not change in any time points. Total TV and sRPE during PRE was 53.52±1.07 Km and 5397±899, total TV and sRPE during week 1 was 82.4±0 Km and 6488±779 and during week 2 was 76.76±0.13 Km and 5760±1483 respectively.

**CONCLUSION:**

Objective and subjective sleep quality parameters worsened during the first days of a 14-day AT in a group of elite swimmers while sleep quantity parameters did not vary. Future studies should investigate athletes' sleep at higher altitudes since sleep disturbances may occur predominantly above 2000 meters. The small study sample and the lack of baseline sleep data are two major limitations of the present study.

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**PERSONALITY TRAITS, STRESS APPRAISALS AND SLEEP IN ELITE ATHLETES: A PROFILE APPROACH**

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INSEP

**INTRODUCTION:**

Impaired sleep is frequent among elite athletes which has been linked to various negative consequences including lower athletic performance and general health. Studies have been conducted with the aim of ascertaining potential acute and chronic factors placed on elite athletes that may result in compromised sleep (Nédélec et al., 2015), but little is known about the relationship between personality traits, stress appraisals and sleep among elite athletes. The aim of this study was to (i) examine athletes' personality profiles (i.e., neuroticism and conscientiousness) from a person-centered perspective, and (ii) investigate whether the profiles that emerge significantly differ in stress appraisals and indicators of sleep.



**METHODS:**

Two hundred and sixty elite athletes from several team and individual sports completed an online questionnaire package including: the NEO Personality Inventory Revised (Costa and McCrae, 1992) to assess neuroticism and conscientiousness traits; the assessment of stress appraisals (i.e., intensity of stress, directional interpretation of stress, challenge appraisal, threat appraisal); and the assessment of various indicators of sleep, i.e. sleep quality, social jet lag, Ford Insomnia Response to Stress Test (FIRST; Drake et al., 2004). A latent profile analysis (LPA) approach was firstly used to identify personality profiles based on the scores of neuroticism and conscientiousness. Secondly, a multivariate analysis of variance was performed to examine if the athletes belonging to the different personality profiles identified with the LPA differ on stress appraisals and indicators of sleep.

**RESULTS:**

Three profiles emerged from the LPA: Profile 1 "maladaptive" (high level of conscientiousness and neuroticism); Profile 2 "highly adaptive" (moderate level of conscientiousness and low level of neuroticism); Profile 3 "adaptive" (high level of conscientiousness and a moderate level of neuroticism). Athletes from profile 3 reported significantly lower scores of stress intensity and threat appraisal than those from other profiles. Athletes from profile 1 reported significantly higher levels of FIRST than those from other profiles as well as higher levels of sleep quality (i.e. worse sleep quality) and lower levels of challenge appraisal than the athletes from profile 2.

**CONCLUSION:**

The present results provide a deeper understanding of the relationship between personality traits, stress and sleep outcomes among elite athletes, and suggest that personality assessment may be useful in identifying individuals at higher risk of worsening sleep. Future studies might seek to improve sleep by preventive actions focusing on specific dysfunctional attitudes, coping styles, and behaviors associated with poor sleep.

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## CP-PN04 Nutrition and Supplements

### RAPID DETERMINATION OF CLENBUTEROL IN FOODSTUFFS OF ANIMAL BY LIQUID CHROMATOGRAPHY TANDEM MASS SPECTROMETRY

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**INTRODUCTION:**

Clenbuterol is clinically used as a kind of antiasthmatics with the function of relaxing bronchial smooth muscle. Nevertheless, over dose administration can also have an anabolic effect due to the promotion of protein synthesis and inhibition of proteolysis. Therefore, it is as a classical anabolic agent prohibited by World Anti Doping Agency (WADA) since late 19th century. Because it is easy to be obtained, thus it can be abused as lean meat enhancer in animal husbandry in many countries. Nevertheless, it will cause a secondary contamination in the tissues of animals administrated by clenbuterol or even poisoning affects for humans after ingestion of animal tissues contaminated by clenbuterol. If athletes have taken the contaminated meat or other edible tissues, it will trigger adverse analytical finding in doping control. Hence, it is necessary to establish a rapid and accurate analytical method to determine the residue of clenbuterol in animal tissues.

**METHODS:**

After homogenate and deproteinization of muscle tissue samples with perchloric acid, one step liquid-liquid extraction was carried out using tert-butyl ether as extraction solution under pH 9-10. An Agilent Zorbax Eclipse Plus C18 100 mm×4.6 mm×1.8 μm analytical column was used for separation. Multiple reaction monitoring mode was adopted to acquire mass spectrum data. The quantitative ions of D9-clenbuterol as internal standard and clenbuterol were 286→204 and 277→203, respectively.

**RESULTS:**

1. Specificity of this method was carried out by analyzing blank matrix samples and blank samples spiked with reference standard solutions of clenbuterol. No potential interfering substances at retention times of the target ions were found in blank matrix and specificity was good.
2. Extraction recoveries of this method in low, medium and high concentration level were 61.7%±5.1%、69.3%±6.2% and 72.4%±5.6%, respectively. Limit of detection is 0.02 ng/g. This method has a good linearity between 0.05 ng/g – 5 ng/g and it's correlation coefficients R2 are more than 0.99. The accuracies of the method are ranged from -5.6% to 3.8%. The precisions are less than 11.2%.

**CONCLUSION:**

1. A rapid, accurate and simple method has been established by using liquid chromatography tandem mass spectrometry and it is suitable for the batch routine determination.
2. Although this method is designed only with one-step liquid-liquid extraction for sample preparation, but it has a good specificity and sensitivity.

### EFFECT OF QUANTIFICATION METHOD ON BLOOD [BETA-HYDROXYBUTYRATE] DETERMINED AFTER ACUTE KETONE MONOESTER INGESTION.

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**INTRODUCTION:**

Nutritional ketosis refers to a state in which blood ketone bodies are elevated above normal basal levels, typically defined as beta-hydroxybutyrate (BHB) >0.5 mM. Acute ketone supplement ingestion rapidly induces nutritional ketosis without otherwise altering diet. There is growing interest in the effect of this practice on exercise responses and performance. The effect is likely due in part to the change in blood [BHB] after supplement ingestion. This can be determined by lab-based calorimetric assay or point-of-care (POC) analysis of capillary, mixed venous, plasma, and serum samples. However, the relationship between various methods and blood fractions is unclear. The purpose of this study was to compare blood [BHB] determined by different methods in response to acute ketone supplement ingestion before and after exercise.

**METHODS:**

Endurance-trained adults (10 males, 7 females) ingested 600 mg/kg body mass of a ketone monoester supplement 30 min before a 30-min cycling bout performed at individual ventilatory threshold intensity. Blood samples were obtained before and after exercise via both fingerprick and venipuncture, and appropriately treated to yield four different types of samples for analyses. Capillary and whole blood was immediately analyzed using a POC analyzer (beta-ketone strip, Freestyle Precision Neo; Abbott Laboratories, IL, USA). Plasma and serum were also analyzed using POC immediately after preparation, and subsequently stored at -80°C for colorimetric analysis occurred within 25 d (Abnova, cat no KA1630; Fisher Scientific, Ontario, Canada), which occurred within 25 d.

**RESULTS:**

[BHB] determined in plasma and serum samples via POC analyzer were similar ( $p>0.99$ ), but higher than all other [BHB] measures ( $p<0.0001$ ), which were not different from one other ( $p>0.61$ ). [BHB] obtained via colorimetric assay in plasma and serum samples from the same blood draw were not different from each other ( $p>0.99$ ) and averaged to create a single value. Using Bland-Altman plots, the mean difference [95% CI] between BHB via colorimetric assay and capillary, whole blood, and plasma BHB via POC analyzer was 0.0 [-2.0-2.1], 0.2 [-1.3-1.8], and 1.3 [0.2-2.7] mM respectively. Log(BHB), averaged from plasma and serum via colorimetric assay, was linearly regressed to capillary ( $p=0.01$ ,  $R^2=0.20$ ,  $p=0.01$ ;  $y=4.3x + 1.4$ ), whole blood ( $p<0.0001$ ,  $R^2=0.43$ ,  $p<0.0001$ ;  $y=5.6x + 0.82$ ), and plasma [BHB] via POC analyzer ( $p<0.0001$ ,  $R^2=0.42$ ,  $p=0.0001$ ;  $y=3.9x + 2.9$ ).

**CONCLUSION:**

Mean [BHB] determined via POC analyzer and colorimetric assay were similar, but there was considerable variability between methods for a given sample.

### **THE TIME-TO-PEAK BLOOD BICARBONATE, PH, AND STRONG ION DIFFERENCE FOLLOWING THE INGESTION OF SODIUM BICARBONATE IN HIGHLY-TRAINED ADOLESCENT SWIMMERS.**

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**INTRODUCTION:**

Contemporary research has sought to optimise sodium bicarbonate ( $\text{NaHCO}_3$ ) supplementation by personalising dosing protocols based upon an individual time-to-peak alkalosis. However, it is difficult to ascertain when this time-point occurs since numerous physiological determinants have been previously used to measure acid-base balance. Therefore, the purpose of this study was to investigate the time-to-peak of three different acid-base variables following  $\text{NaHCO}_3$  supplementation.

**METHODS:**

Twelve highly-trained, adolescent swimmers (age:  $15.9 \pm 1.0$  years, height:  $1.73 \pm 0.6$  m, body mass:  $65.3 \pm 9.6$  kg) volunteered for this study. Participants mimicked their typical pre-competition nutrition before ingesting 0.3 g/kg BM-1  $\text{NaHCO}_3$  in gelatine capsules. Capillary blood samples were then taken during quiet, seated rest on nine occasions (0, 60, 75, 90, 105, 120, 135, 150, and 165 mins post-ingestion) for the assessment of blood pH, bicarbonate ions ( $\text{HCO}_3^-$ ), and the strong ion difference (SID).

**RESULTS:**

On a group mean level, no differences were found in the time-to-peak of either approach (pH =  $120 \pm 38$  mins,  $\text{HCO}_3^-$  =  $130 \pm 35$  mins, SID =  $96 \pm 35$  mins;  $p = 0.06$ ). There was, however, a large effect size ( $g = 0.91$ ) between  $\text{HCO}_3^-$  and the SID suggesting a difference in practical application.

**CONCLUSION:**

This earlier peak in the SID presents an interesting avenue for further research, as this may elucidate a more optimal dosing strategy based upon the current theory towards exercise fatigue. Thus, future investigations should aim to identify whether either of these personalised strategies is more ergogenic with regards to performance enhancement.

### **SUPPLEMENTATION WITH A MANGO LEAF EXTRACT (ZYNAMITE®) IN COMBINATION WITH QUERCETIN ATTENUATES MUSCLE DAMAGE AND PAIN AND ACCELERATES RECOVERY AFTER STRENUOUS DAMAGING EXERCISE**

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**INTRODUCTION:**

Vigorous and unaccustomed exercise involving eccentric muscle contractions may cause muscle damage. This concurs with increased local inflammation and muscle soreness, reducing force production and compromising recovery. The ergogenic effect of antioxidants administration to reduce exercise-induced muscle damage (EIMD) remains under debate, although recent studies have reported positive effects using large daily doses (1000mg) during at least 3 days, which may compromise exercise-induced hormesis. Zynamite®, a mango leaf extract rich in the natural polyphenol mangiferin, has antioxidant and anti-inflammatory properties, which may prevent EIMD and ease recovery. Thus, we aim to determine if Zynamite® administered in combination with quercetin accelerates recovery after repeated damaging exercise.

**METHODS:**

Twenty-four women and 33 men were randomly assigned to two treatment groups matched by sex and 5-km running performance, and run a 10-km race followed by 100 drop jumps to elicit EIMD. One hour prior to competition, and every 8h after for 24h, they ingested placebo or 140 mg of Zynamite®+ 140 mg of quercetin with a double-blind design. Fasting blood samples were obtained before the 10-km race and 24h after. Biomarkers of muscle damage were assessed in serum: myoglobin, high-sensitivity C-reactive protein (hs-CRP), creatine kinase (CK) and alanine aminotransferase (ALT). Race performance, muscle pain (analogic scale) and countermovement vertical jump performance (force plate, Kistler) were assessed before and after competition.

**RESULTS:**

Performance time in the competition were unaffected by the treatment, while polyphenols attenuated the muscle pain after the competition ( $6.8 \pm 1.5$  and  $5.7 \pm 2.2$  a.u.,  $p=0.035$ ) and the loss of jumping performance ( $9.4 \pm 11.5$  and  $3.9 \pm 5.2\%$ ,  $p=0.036$ ;  $p=0.034$ ) and mechanical impulse ( $p=0.038$ ) 24h later. In men, polyphenols attenuated the increase of serum myoglobin ( $24.4 \pm 21.2$  to  $48.3 \pm 42.9$  ng/mL,  $p<0.001$ ; time by treatment by sex interaction;  $p=0.045$ ) and alanine aminotransferase (from  $19.3 \pm 14.3$  to  $24.8 \pm 15.7$  and from  $23.3 \pm 13.6$  to  $24.7 \pm 16.1$  U/L, placebo and polyphenol treatment, respectively,  $p < 0.001$ ; time by treatment interaction,  $p = 0.01$ ). The concentration of hs-CRP and CK were increased 24h post-race without a significant effect of polyphenols ( $p=0.53$  and  $p=0.95$ , respectively).

**CONCLUSION:**

The ingestion of a combination of 140mg Zynamite® and 140mg of quercetin, consumed 1h before a 10-km running competition, followed by 3 doses every 8h, attenuates the pain and muscle damage elicited by the race and accelerates the recovery of muscle performance. These effects are likely due to the anti-inflammatory and antioxidant effects of mangiferin and quercetin, which inhibit the ROS-producing enzymes, xanthine oxidase and NADPH oxidase. Our results may also imply a synergistic effect of Zynamite® and quercetin, and report for the first time an ergogenic effect of low dosing and short supplementation with quercetin.

**EFFECTS OF POST-EXERCISE PROTEIN SUPPLEMENTATION ON BONE TURNOVER IN ADOLESCENT SWIMMERS**

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**INTRODUCTION:**

Protein supplementation has generally been examined in relation to muscle development and performance, albeit protein may also have an effect on other tissues which undergo stress during exercise. However, the effects of whey protein supplementation alone, consumed post-exercise, on bone turnover has not been examined, in either adult or youth athletes. Considering that adolescence is the most important period for the attainment of peak bone mass and that relative energy requirements of youth athletes, compared to adults, are higher during and following exercise, it is important to examine whether post-exercise whey protein supplementation is beneficial to bone turnover in this population. This study examined the effects of whey protein consumed after an intense swimming trial on markers of bone turnover in adolescent swimmers.

**METHODS:**

Fifty-eight male (n=28, 14.0±1.5 years) and female (n=31, 13.8±1.8 years) swimmers were stratified into three groups matched for age, body mass and sex: a protein group consumed whey protein (0.6 g/kg), a carbohydrate group consumed maltodextrin (0.6 g/kg), and a control group consumed flavoured water. Beverages were consumed in two equal servings (0.3 g/kg each), provided immediately after swimming. Participants provided a morning, fasted, resting blood sample then performed an intense swimming trial consisting of a maximal 200m swim followed by a high intensity interval swimming protocol (5x100m, 5x50m and 5x25m; 1:1 work-to-rest ratio). Following swimming, they consumed their first respective post-exercise beverage and 2h later, they performed a second maximal swim followed by the second beverage. Approximately 3h after the second beverage, two post-consumption blood samples were collected at 8h and 24h from baseline. Markers of bone formation (procollagen type 1 intact N-terminal propeptide [PINP]) and resorption (carboxy-terminal collagen crosslinks [CTXI]) were measured in serum. Bone turnover rate and balance were estimated using the multiple of medians of PINP and CTXI.

**RESULTS:**

For the CTXI concentrations at 8h and 24h expressed relative to the baseline concentration, we observed a significant time-by-group interaction (p=0.001), reflecting a higher concentration (+11%) at 8h in all groups, followed by a significant decrease (-22%) at 24h in the protein group only. No significant effects or interactions were found for PINP. The calculated bone turnover balance ratio was >1, reflecting a higher formation than resorption at all times. The calculated bone turnover rate showed a significant time-by-group interaction (p<0.001), reflecting an increase at 8h and 24h compared to baseline (+32% and +18%, respectively) in the protein group, with no change in the carbohydrate group and a significant decrease (-20%) at 8h in the water group.

**CONCLUSION:**

These results shed light on the potential importance of protein consumption shortly after intense exercise in promoting bone turnover up to 24h following the exercise in adolescent athletes.

**1-WEEK SPIRULINA SUPPLEMENTATION IMPROVES OXYGEN UPTAKE KINETICS AND  $\dot{V}O_{2\text{MAX}}$  IN UPPER BODY EXERCISE AND PERFORMANCE.**

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**INTRODUCTION:**

Global demand for algae is continuously increasing and it has been reported that algae has started to be consumed beyond the traditional benefits for nutrition and health. Spirulina, a rich blue-green algae supplement, has previously been reported to improve high intensity exercise performance during cycling or running. However, Spirulina's effect on upper body exercise performance is yet to be investigated. Therefore, the purpose of this study was to investigate the physiological responses to the supplementation of Spirulina on upper body exercise performance.

**METHODS:**

In a double-blinded randomized cross over design, eleven trained males ingested 6g/day of Spirulina or Placebo for seven days. Each participant performed a baseline  $\dot{V}O_{2\text{max}}$  test, a familiarization visit and then after supplementation, 2 x 30-minute exercise bouts corresponding to 55% of their  $\dot{V}O_{2\text{max}}$ , shortly followed by a  $\dot{V}O_{2\text{max}}$  performance test. A minimum seven-day wash out period was required between conditions. Oxygen uptake, RER and HR were measured continuously during exercise and Hemoglobin was measured prior to exercise after both the Spirulina and Placebo conditions.

**RESULTS:**

Ingestion of Spirulina significantly increased Hb from Placebo (144 g/l ± 6.9 Vs 154 g/l ± 10.5, P<0.05). After Spirulina supplementation, Oxygen consumption and heart rate were significantly lower during the 30 minute bouts of exercise (2169.86 ml/min ± 173.3 Vs 2310.9 ml/min ± 188.89, P<0.05 & 154bpm ± 14 Vs 149bpm ± 17, P<0.05) and  $\dot{V}O_{2\text{max}}$  scores were significantly higher (34.1 ml/min/kg ± 6.03 Vs 37.37 ± 5.98, P<0.05). RER for Spirulina (1.00 ± 0.06) was not statistically significantly different (P=0.874) to Placebo (1.01 ± 0.07) during the 30 minute bout of exercise.

**CONCLUSION:**

Spirulina supplementation significantly improves upper body exercise performance possibly via the enhanced Hb concentration improving oxygen kinetics during the submaximal exercise bouts and allowing for the enhanced performance in a  $\dot{V}O_{2\text{max}}$  performance test. This study contributes to the relatively small and ostensible volume of research thus far conducted on the ergogenic aid capabilities of SP and gives further exploration and insight into the proposed potential mechanisms of action.

### SYNERGISTIC EFFECT OF THE INTAKE OF FUNCTIONAL FOODS INCLUDING INULIN AND ROWING EXERCISE FOR BODY COMPOSITION AND BONE MINERAL DENSITY IN ELDERLY JAPANESE WOMEN

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#### INTRODUCTION:

Sarcopenia and osteoporosis have been reported to be associated with decreasing quality of life in elderly people, especially elderly women. Previous studies reported that inulin intake increased bone mineral density (BMD) and resistance exercise did the same including lean body mass (LBM). However, the synergistic effect of these on LBM and BMD in elderly people has not been shown. Rowing exercise (RE) is relatively safe for elderly people with an impairment to their knees or legs. The purpose of this study was to examine the effect of the intake of functional foods including inulin [FF] in combination with RE for body composition and BMD in elderly Japanese women.

#### METHODS:

We performed an interventional study consisting of fifty elderly women aged between sixty-five and seventy-nine who were classified into four groups; FF with RE group (G1), RE with placebo (G2), FF without RE group (G3), and control group (G4). Subjects in FF groups were required to intake functional foods containing 5-grams of inulin per day (Energy [E] 110 kcal, Protein [P] 3.5g, Fat [F] 2.8g, Carbohydrate [C] 20g including inulin 5g, Calcium [Ca] 200mg) and subjects in placebo groups were required to intake foods containing 5-gram resistant digestion dextrin [RDD] per day (E 110 kcal, P 3.5g, F 2.8g, C 17.5g including 5-gram RDD, Ca 200mg). Subjects in RE groups were required to exercise using a rowing ergometer for ten minutes per week in a laboratory and exercise at home using a resistance tube for ten minutes twice per week. Almost all subjects live active lives. We measured their BMD and body composition using dual-energy X-ray absorptiometry.

#### RESULTS:

We found a significant difference in LBM between the 4 groups ( $p=0.035$ ) The following changes occurred; G1 was  $-0.04 \pm 0.61$  kg, G2 was  $-0.34 \pm 0.64$  kg, G3 was  $-0.35 \pm 0.76$  kg and G4 was  $-0.83 \pm 0.60$  kg. The change of G1 was significantly small compared with that of G4 ( $p=0.030$ ). And we also found a significant difference in the change volume of BMD between the 4 groups ( $p=0.001$ ). Recorded change in G1 was  $0.002 \pm 0.013$  g/cm<sup>2</sup>, in G2  $0.008 \pm 0.011$  g/cm<sup>2</sup>, in G3  $0.004 \pm 0.009$  g/cm<sup>2</sup> and in G4  $-0.013 \pm 0.016$  g/cm<sup>2</sup>. BMD of G1, G2, and G3 increased. However, G4 decreased. The change in G2 was significantly different from that of G4 ( $p=0.001$ ).

#### CONCLUSION:

The elderly women naturally experience a decrease in their BMD and LBM. Previous studies showed that FF stimulates the absorption of Ca ion in the intestinal tract. Subjects in this study may also have experienced an improvement in their Ca nutrition status caused by increased FF. The subjects hadn't joined in RE before the tests, as it is not a popular activity. This exercise to these elderly women may have targeted muscle groups otherwise not used in daily activity.

In conclusion, FF in combination with RE prevented from decreasing of BMD and LBM in elderly Japanese women.

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### DIETARY (-)-EPICATECHIN BOOSTS NAD<sup>+</sup> METABOLISM AND STIMULATES MITOCHONDRIAL BIOGENESIS IN SKELETAL MUSCLE FROM MICE.

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#### INTRODUCTION:

Mitochondria are subcellular organelles that play a central role in providing ATP to sustain the bioenergetics needs of cells, especially during exercise. Endurance exercise promotes mitochondrial biogenesis to improve whole body aerobic capacity. Concomitantly to training, there is an interest to identify nutritional strategies able to maximize mitochondrial function. Recently, (-)-epicatechin (EPI), a member of the flavanol group that itself is a part of the chemical family of flavonoids, has gained attention. While this natural polyphenolic compound may have positive impact on mitochondria, the underlying mechanisms remain poorly understood. We therefore evaluated the effect of an EPI supplementation on mitochondrial function and putative mechanisms including NAD metabolism.

#### METHODS:

We explored the effects of 14 days of EPI supplementation (1mg/g bw per day) twice a day in C57BL/6 mice. Whole-body effects were assessed by indirect calorimetry and an oral glucose tolerance test (OGTT) was performed to assess glucose metabolism. Mitochondrial function was assessed in permeabilized fibers of oxidative and glycolytic muscles and enzyme activities were determined in glycolytic muscle. mRNA of genes involved in mitochondrial biogenesis were measured by RT-qPCR in glycolytic muscle. NAD<sup>+</sup> and NADH content were measured by commercial kit in glycolytic muscle.

#### RESULTS:

EPI supplementation modified whole body metabolism and promoted carbohydrate (CHO) use ( $61 \pm 17\%$  of energy consumption depended on CHO oxidation in EPI group vs.  $42 \pm 18\%$  in control group,  $p<0.01$ ) and increased metabolic flexibility by  $31 \pm 31\%$  ( $p<0.05$ ). The area under the curve of OGTT was lower in EPI group ( $1018 \pm 134$  vs.  $1181 \pm 170$  mmol.L-1.2h,  $p<0.01$ ). A main effect of EPI supplementation was observed on mitochondrial respiration, both in soleus and gastrocnemius. Complex I, II, IV and citrate synthase activity were increased in gastrocnemius muscle ( $+31 \pm 27\%$ ,  $+28 \pm 38\%$ ,  $+35 \pm 38\%$ ,  $+14 \pm 13\%$  respectively). H<sub>2</sub>O<sub>2</sub> production was reduced with EPI when the production was expressed by mitochondrial content in gastrocnemius muscle. An increase of 14% of NRF1 mRNA expression ( $p<0.05$ ) and a trend for an increase of citrate synthase mRNA ( $p=0.078$ ) were observed whereas PGC1 $\alpha$ , TFAM, Catalase or MnSOD mRNA did not change. The NAD<sup>+</sup> and NADH content were increased (respectively by  $29 \pm 42\%$  and  $72 \pm 39\%$ ,  $p<0.05$ ) and the NAD<sup>+</sup>/NADH ratio tended to increase in EPI group ( $p=0.08$ ).

#### CONCLUSION:

EPI supplementation boosted the NAD metabolism and improved mitochondrial function which probably contributed to the whole-body metabolism adaptation with a greater ability to use CHO. Future studies should evaluate the interest of EPI supplementation strategy in human.

**METABOLIC LOAD OF MALE ELITE ROWERS DURING ERGOMETER ROWING AND IMPLICATIONS FOR TRAINING PRESCRIPTION**

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**INTRODUCTION:**

Male elite rowers are relatively tall and heavy endurance trained athletes who present with a high absolute aerobic capacity. Rowing training typically amounts to approx. 650 min/wk with peaking volumes of up to 900 min/wk, normally complemented by strength and unspecific endurance training like cycling. To calculate energy expenditure (EE), substrate utilization and required energy intake during such training, data on metabolic load of rowing training are necessary, however these data are scarce.

Therefore, we aimed to measure the metabolic load of ergometer rowing in elite rowers at lactate thresholds 1 and 2 (LT1, LT2) often used for training intensity prescription and payed special attention to substrate utilization.

**METHODS:**

We analyzed 79 incremental rowing tests (5x6 min or 6x4 min, 200-400 W or 200-450 W, 50 W increment) of 11 elite male rowers (age 27±5 years, standing height 192±4 cm, body mass 91.8±6.3 kg, VO<sub>2</sub>max 72±4 mL/min/kg) conducted within a period of three years for oxygen consumption (VO<sub>2</sub>) and respiratory exchange ratio (RER) at LT1 and LT2 (1) to calculate EE and estimate substrate utilization (2). Results are given as 95% confidence intervals (95% CI).

**RESULTS:**

At LT1 and LT2 mechanical power output amounted to 262–271 W and 355–365 W (95% CI), capillary blood lactate concentration was 0.85–0.92 mmol/L and 2.35–2.43 mmol/L, VO<sub>2</sub> was 4215–4380 mL/min and 5467–5621 mL/min, RER was 0.88–0.89 and 0.95–0.96, EE was 21.3–22.2 kcal/min and 28.1–28.9 kcal/min. Translated to a typical 100 min rowing training session at LT1, the EE of a male elite rower ranges from 2132–2216 kcal, with 62–64% originating from carbohydrates (CHO) and 38–36% from lipids (LIP). Energy expenditure for an exemplary 30-min session at LT2 equals to an EE of 842–868 kcal with 85–88% originating from CHO and 15–12% from LIP.

**CONCLUSION:**

Energy expenditure in elite rowers is already high at LT1 and LT2 ergometer rowing and can be as high as 4261 to 4433 kcal/day (95% CI) for 200 min daily rowing training at LT1 during training camps. Considering resting energy expenditure (REE) of approx. 2500 kcal and additional exercise induced EE, management of adequate total energy intake becomes likely challenging for elite rowers. Notably, if energy intake is insufficient e.g. during high volume training camps, rowers may develop a Relative Energy Deficiency in Sport (RED-S) with potential negative impacts on performance and training. Consequently, EE needs to be considered when prescribing training and periodized nutrition for rowers because otherwise EE might surpass the possibility of energy intake. Of note, these ergometer data needs to be further validated e.g. for on-water rowing.

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2 Peronnet et al. 1991: *Can J Sport Sci*,16, 23-29

**THE EFFECTS OF THREE DIFFERENT DOSES OF CAFFEINE ON FOUR TYPES OF JUMPING PERFORMANCE**

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**INTRODUCTION:**

Caffeine has psychostimulating properties, which explains the desire of specialists to use it in sports. Meanwhile, caffeine is a substance that WADA has included in the monitoring program for years (<https://www.wada-ama.org>). The positive influence of caffeine on endurance performance in sport can be considered proven (1 et al.), while its effects on different kinds of power abilities are less studied. Therefore, the purpose of this study was to examine the effects of different caffeine doses on four different types of jumping performance which are typical exercises demonstrating power abilities.

**METHODS:**

15 male students of physical education institute (age 19±1, height 1.77±0.06 m, body mass 74±7 kg) took part in the research and completed all testing sessions. Four experimental conditions, each corresponding to one testing session for each participant, were tested: a placebo (Dextrose) and three caffeine doses of 2, 4, and 6 mg•kg<sup>-1</sup>. The experiment had a randomized, crossover, double-blind study design. All sessions were held on the same day of the week and at the same time of the day. 45 minutes after the caffeine or placebo (dissolved in 200 ml of water) ingestion, each participant had an individual 15-minute warming up session followed by jumps performed in the following sequence: countermovement jump with armswing, squat jump without armswing, drop jump (0.40 m height), and 20 serial jumps. Jumping height was estimated through 2D video analysis (240 Hz video camera, Kinovea – 0.8.20 software). The differences in coordinates of a marker (fixed on the belt of every subject) between the usual stance and jump were evaluated. One-way ANOVA was used to analyze the differences between the conditions.

**RESULTS:**

The participants showed the following results (mean ± S.D.): countermovement jump – 0.51±0.04, 0.50±0.05, 0.52±0.05 and 0.52±0.06 m for placebo and 2, 4 and 6 mg•kg<sup>-1</sup> caffeine doses, respectively, p=0.744; squat jump – 0.38±0.04, 0.39 ±0.04, 0.39±0.03 and 0.39±0.04 m for placebo and small, medium and large caffeine doses, respectively, p=0.941; drop jump – 0.51±0.05, 0.52±0.06, 0.53±0.06 and 0.53±0.06 m for placebo and for each caffeine dose, respectively, p=0.904; serial jump – 0.39±0.05, 0.40±0.07, 0.40±0.06 and 0.41±0.06 m for placebo and 2, 4 and 6 mg•kg<sup>-1</sup> caffeine doses, respectively, p=0.888.

**CONCLUSION:**

One-way ANOVA in this study indicated that different doses of caffeine intake did not change the height of any of the four jumps used. While a number of authors in earlier studies observed a significant effect in vertical jump test when using small, medium and large doses of caffeine (2). Thus, using caffeine as a psychostimulant in sports which require various kinds of power abilities can only be based on studying individual reactions to this substance.

**References:**

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**VITAMIN D SATURATION IN ATHLETES**

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**INTRODUCTION:**

Vitamin D is not only an effective remedy for rickets, but its deficiency adversely affects virtually all disease events in the human body. Vitamin D receptors have been found in most tissues, including skeletal muscle. A number of experimental studies have confirmed its possible effect on muscle performance. The importance of vitamin D deficiency in clinical medicine is steadily increasing and the indication of optimal saturation is gaining in importance.

**METHODS:**

We examined several groups of athletes at different times of the year and compared the levels of vitamin D in relation to the accepted lower plasma standard (60 nmol / l). The athletes were measured at different times of the year. They were winter swimmers (n = 15) in March and a group of volunteers from various sports (n = 28) in April, i.e. at the end of the winter period. A group of ultramarathon-runners was examined in October (n = 18) after the "summer" period and in March (n = 9) after the end of the "winter" period. 12 persons from the group of winter swimmers were subjected to follow-up examination after several weeks of supplementation with Vigantol. In January at the beginning of the preparatory period, the team of the first football division was also examined (n=28).

**RESULTS:**

Only 20% of winter swimmers and 18% of other athletes reached at least the lower limit of physiological vitamin D levels after winter. In the ultramarathon group, only 22% of the runners did not reach the physiological minimum after the summer period, while not even one reached the required level after the winter period. For the football team, seven players (25%) did not reach 60 nmol / l. The highest values were achieved by players who spent a week of Christmas holiday in Dubai or the Maldives (86.15 to 122.54 nmol/l).

**CONCLUSION:**

1. The level of vitamin D in the monitored groups of athletes after the winter period in 80-100% of cases does not reach the physiological normative. 2. For athletes engaged in outdoor sports (ultramarathon runners), vitamin D deficiency is rather rare at the end of the summer. 3. Vitamin D supplementation in winter period can be recommended almost without exception to all athletes, even those who are exposed to daylight almost entirely during their training and competitions (winter swimmers). 4. Given a number of other functions of vitamin D (crucial role in calcium and phosphorus metabolism, maintaining muscle strength, regulating growth, cardiomyocyte proliferation and morphology, regulating blood pressure), it can be assumed that vitamin D can significantly affect performance not only of athletes, but certainly also of the untrained population. 5. In terms of personalized medicine, however, even in a relatively homogeneous group (high-performance footballers), significant differences can be found among players in which exposure to sunlight in locations of lower latitude, differences in nutrition, different race etc. play the role.

**THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND EATING HABITS ASSESSED USING SIMPLE QUESTIONNAIRES AMONG JAPANESE ADULTS**

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**INTRODUCTION:**

It is known that appropriate eating habits, an active lifestyle, and getting sufficient rest are important for maintaining and promoting health. In assessing subjects, it is necessary to determine their exercise and eating habits accurately and quickly for effective health education. Therefore, we developed a simple questionnaire that makes it easy to assess physical activity and diet. In our previous study using the simple questionnaires we developed, there was a significant and positive correlation between physical activity score (PA score) and daily step counts, and between food balance score (FB score) and nutrient intakes. Therefore, it is evident that our simple questionnaires are useful for assessing physical activity and dietary habits of Japanese adults. The purpose of this study was to examine the relationship between physical activity and eating habits using the simple physical activity questionnaire and the simple food balance questionnaire we developed.

**METHODS:**

The simple physical activity questionnaire and simple food balance questionnaire were administered to 65 healthy Japanese people (20-59 age). Physical activity scores (PA score; up to 28 points) were calculated from the simple physical activity questionnaire, and food balance scores (FB score; up to 10 points) were calculated from the simple food balance questionnaire. The relationships between the PA score and the FB score were assessed by Pearson's correlation coefficient.

**RESULTS:**

PA scores ranged from 1 to 26 points ( $11.5 \pm 5.7$ ). FB scores ranged from 0 to 9 points ( $3.5 \pm 2.0$ ). There was a significant and positive correlation between the PA score and the FB score ( $r=0.39$ ,  $p<0.01$ ).

**CONCLUSION:**

It was found that the higher the PA score, the higher the FB score. This suggests that those who engaged in more physical activity, tended to have better eating habits.

**PROTEIN SUPPLEMENTATION ENHANCES THE EFFECTS OF INTERMITTENT LOADING FOR SKELETAL MUSCLE THROUGH ACTIVATION OF THE MTOR SIGNALING PATHWAY IN RAT DISUSE ATROPHY MODEL**

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**INTRODUCTION:**

The total mass of skeletal muscle is mediated by the balance between protein synthesis and degradation. Physical disuse model using hindlimb unloading (HU) leads to muscle atrophy in the skeletal muscle, while intermittent loading (IL) during HU attenuated the muscle atrophy (1). Protein supplementation may also attenuate the muscle atrophy, but combination of protein supplementation with IL on the regulation of skeletal muscle protein metabolism have not been studied. The mTORC1 signaling pathway serves as a central regulator of skeletal muscle protein synthesis (2). It has been also shown that stimulation of protein degradation during skeletal muscle atrophy is induced through activation of the ubiquitin-proteasome system and autophagy system (3). We investigated the effects of IL in combination

with high-protein oral nutritional supplement (HP) administration during HU on the changes in skeletal muscle mass and intracellular signaling pathways of protein synthesis and breakdown.

**METHODS:**

Male F344 rats aged 9 weeks were assigned into 4 groups: control (CON, n=6), HU (HU, n=9), IL during HU (IL, n=10), and IL during HU followed by HP supplementation (protein: 2.64 g/kg/day) (IL+HP, n=10). All rats were fed AIN-93G-based low-protein diets (protein: 4.11 g/kg/day) throughout the experiment. HU was performed for 14 days by lifting the tail so that the hindlimbs were unloaded. IL was carried out by releasing from unloading for an hour everyday. Soleus (SOL) and gastrocnemius (GS) muscles were sampled 30 min after last IL and HP supplementation. We evaluated skeletal muscle mass, and gene and protein expression levels of the molecular factors for protein synthesis (p70S6K1 (Thr389) and rpS6 (Ser240/244)), protein degradation (Atrogin-1 and MuRF1), and autophagy (LC3B).

**RESULTS:**

SOL and GS muscle mass relative to BW was lower in the HU group than in the CON group ( $p<0.05$ ), and it was higher in the IL group than in the HU group ( $p<0.05$ ). Relative GS muscle mass was greater in the IL+HP group than in the IL group ( $p<0.05$ ). Phosphorylation levels of p70S6K1 and rpS6 were higher in the IL group compared with the HU group in SOL and GS muscles ( $p<0.05$ ), and even higher in the IL+HP group compared with the IL group in GS muscle ( $p<0.05$ ). Although Atrogin-1 mRNA expression level and the LC3B II/I ratio were higher in the HU group compared with the CON group in both SOL and GS muscles ( $p<0.05$ ), no significant difference was found between the IL group and the IL+HP group.

**CONCLUSION:**

The findings indicated that the protein supplementation in combination with IL was effective to prevent skeletal muscle atrophy induced by physical disuse. This effect was found in rat GS muscle, and may have resulted from enhanced activation of the mTORC1 downstream targets p70S6K and rpS6.

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**ACUTE EFFECT OF CITRULLINE MALATE SUPPLEMENTATION ON REPETITIONS TO FAILURE DURING STRENGTH TRAINING: A SYSTEMATIC REVIEW AND META-ANALYSIS**

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**INTRODUCTION:**

Citrulline malate is a dietary supplement with increasing popularity both among strength athletes and in the research field. The supplement is suggested to enhance strength training performance, where one of the potential mechanisms being a decrease in muscle fatigue. However, there is conflicting evidence of citrulline malate's effect on repetitions to failure. The current meta-analysis aimed to determine whether supplementing with citrulline malate prior to strength training could increase the total number of repetitions performed before reaching voluntary muscular failure.

**METHODS:**

A systematic search was conducted where the inclusion criteria were double-blind placebo-controlled studies in healthy participants that examined the effect of citrulline malate on repetitions to failure during upper- and lower-body resistance exercises. If a study had examined more than one exercise, all exercises were included separately but the variance was multiplied by the total number of exercises so that the total weighting of the study was similar to a single aggregated effect size. The Hedge's G standardized mean differences (SMD) between the placebo and citrulline malate trials were calculated and used in a random effect model. Two sub-analyses were performed, one for upper-body- and one for lower-body-exercises. Heterogeneity and publication bias were assessed with Egger's regression test in addition to the Duval and Tweedie's Trim and Fill method.

**RESULTS:**

Eight studies, including 137 participants that consisting of strength trained (>0.5-1-year experience) men (n=101) and women (n=27) in addition to untrained participants (men, n=9) fulfilled the inclusion criteria. Across studies, 14 different single- and multi-joint exercises (7 upper-body and 7 lower-body) were performed. Supplementing with citrulline malate increased number of repetitions compared to placebo ( $p=0.045$ ), with a small SMD (0.195; 95% CI: 0.004, 0.386). Only the sub-analysis for the lower body exercise resulted in a tendency for an effect of the supplement ( $p=0.0508$ , SMD 0.266; 95% CI: -0.0009, 0.534), with no effect for the upper body ( $p=0.27$ , SMD 0.15). Eggers test for funnel plot asymmetry yielded a nonsignificant result ( $z=1.56$ ,  $p=0.11$ ), however, the Duval and Tweedie's trim and fill analysis method observed four missing studies to the left of the funnel plot.

**CONCLUSION:**

The meta-analysis observed a small ergogenic effect of 7.6% (SMD 0.195) with citrulline malate supplementation on number of repetitions to failure, which may increase training volume and long-term adaptations. Only the lower body sub-analysis reached a tendency for an effect of citrulline malate, but with no meaningful or practical difference to the upper body (8.2% vs 6.9%, respectively). The magnitude of the effect seems to be slightly lower than other ergogenic dietary supplements such as caffeine (SMD ~0.2-0.4) and creatine (SMD ~0.3). However, more research is needed to elucidate whether citrulline malate improves long-term adaptations.

**THE EFFECTS OF A NEW MULTI-INGREDIENT PRE-WORKOUT SUPPLEMENT ON MUSCULAR FUNCTION AND SUBSTRATE OXIDATION ACROSS A MICROCYCLE IN MIDDLE-AGED ADULTS**

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**INTRODUCTION:**

Pre-workout multi-ingredient supplementation is currently used for enhancing exercise performance or increase fat oxidation on physically active individuals.

**METHODS:**

We compared the effects of a pre-workout multi-ingredient, including isomaltulose, amino acids, caffeine and yerba mate extract (PREW) vs. an isoenergetic carbohydrate only placebo (CHO) over a 5-day microcycle in middle-aged adults. In a double-blinded, crossover design, 4 male and 6 women ( $48.91\pm 3.98$  years old) were balanced and randomly assigned to either a PREW or a CHO conditions before completed

two identical 5-day intervention periods involving 3 non-consecutive (Monday, Wednesday, Friday) resistance training (RT) and 2 non-consecutive (Tuesday, Thursday) 30-min endurance training (END). The Supplement was ingested ~15 min. before exercise. Each period was separated by a two-week washout non-supplementation phase. The primary outcomes were the total kg lifted (VOL), strength and power performance measured after RT and the proportion of fat (FAO) and carbohydrate (CHO<sub>ox</sub>) oxidised during END. The secondary outcome was the Tensiomyography (TMG) [muscle displacement (Dm), contraction time (Tc), and contraction velocity (Vc)] of the vastus medialis (VM), biceps femoris long head (BFLH) and anterior deltoids (AD) measured after RT.

#### RESULTS:

Significant higher VOL were performed under the PREW condition in RT-2 ( $p=0.02$ ;  $d=0.9$ ) and RT-3 ( $p=0.04$ ;  $d=0.7$ ). Furthermore, a close to significant higher VOL, also favouring PREW, was observed in RT-1 ( $p=0.06$ ;  $d=0.7$ ). Both conditions showed significant reductions of the performance measured in medicine ball throw (MBT) and isometric force (MIF) after RT-1 and RT-2. Nonetheless, compared to CHO, PREW significantly attenuated the decrease in MIF after RT-1 ( $p=0.01$ ;  $d=0.9$ ) and RT-3 ( $p=0.02$ ;  $d=0.8$ ), and MBT after RT-2 ( $p=0.02$ ;  $d=0.9$ ) showing a close to significant effect ( $p=0.06$ ;  $d=0.6$ ) to attenuate the decrease of MIF at post RT-2 and MBT post RT-1 ( $p=0.1$ ;  $d=0.5$ ). The TMG analysis revealed a significantly lower Vc in BFLH after RT-2 ( $p=0.04$ ;  $d=0.7$ ), and RT-3 ( $p=0.02$ ;  $d=0.9$ ) in CHO vs PREW. Furthermore, during END-2 the PREW condition showed a close to significant increase in FAO ( $p=0.06$ ,  $d=0.7$ ) along with a decreased CHO<sub>ox</sub> ( $p=0.06$ ,  $d=0.7$ ).

#### CONCLUSION:

Ingesting a multi-ingredient ~15 min before RT improved performance, attenuated the decrease in MIF and upper body power and may protect from disruptions of the lower body muscle contractile properties. Additionally, compared to CHO alone, PREW enhanced the FAO and reduced the CHO<sub>ox</sub> during a 30-min low-intensity endurance exercise in middle-aged adults.

## CP-PN05 Muscle stimulation and architecture

### EFFICACY OF ARTIFICIAL GRAVITY AS AN EXERCISE COUNTERMEASURE FOR THE DETERIORATING EFFECTS OF 60 DAYS OF BED REST ON LEG MUSCLE STRENGTH AND POWER

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#### INTRODUCTION:

The deconditioning of astronauts in space during long-term missions due to the absence of gravitational forces is a well-known problem and constitutes an obstacle for longer missions, such as a mission to Mars. If the absence of gravitational forces is the cause of the decline in physical performance, one potential countermeasure is artificial gravity (AG), elicited for example, by centrifugation. Studying the efficacy of potential countermeasures directly in space is usually not feasible due to high costs and low sample size, which is why they are first tested during bed rest studies. Here, we assessed the efficacy of two artificial gravity interventions as exercise countermeasures for the decline of leg strength and power after 60 days of bed rest.

#### METHODS:

24 participants ( $33 \pm 9$  y,  $174 \pm 9$  cm,  $74 \pm 10$  kg, 8 female, 16 male) were randomly assigned to one of three different groups: CTRL, cAG, and iAG. All participants were then subjected to 60 days of 6° head-down tilt bed rest. During these 60 days, the participants in the intervention groups were exposed to 30 min of AG per day on a short-arm human centrifuge, with an acceleration of 2g at the foot level. Participants in cAG were subjected to 30 minutes of continuous centrifugation, and those in iAG to 6 x 5 minutes of centrifugation with a 3-minute break in between the 5-minute bouts. Before and after the 60 days of bed rest, we tested maximal isometric knee extension and ankle plantar flexion in custom-made ergometers, as well as maximal leg power during countermovement jumps on a force plate. Changes in performance were assessed with repeated-measures analyses of variance.

#### RESULTS:

The analyses revealed significant group \* time interaction effects for maximal power during the countermovement jumps ( $p=0.005$ ), as well as for isometric maximal voluntary contractions (MVC) during plantar flexion ( $p=0.002$ ). No interaction effects were found for MVC during knee extension ( $p=0.15$ ), and rate of force development during isometric knee extension ( $p=0.75$ ) and plantar flexion ( $p=0.06$ ). The interaction effects seem to be due to a more pronounced decline in CTRL ( $-36 \pm 15\%$  for maximal power, compared to  $-25 \pm 11\%$  in cAG and  $-26 \pm 9\%$  in iAG;  $-46 \pm 7\%$  for plantar flexion MVC compared to  $-30 \pm 15\%$  in cAG and  $-32 \pm 8\%$  in iAG).

#### CONCLUSION:

Both artificial gravity interventions attenuated the pronounced decline in some measures of leg power and strength. However, even in the measures showing a significant attenuation, considerable losses were observed. Thus, centrifugation alone is not an adequate exercise countermeasure and should be combined with other types of exercise in order to be used successfully as a countermeasure for the deteriorating effects of space travel on physical performance.

### DIFFERENTIAL EFFECTS OF ELECTRICAL MUSCLE STIMULATION AND VOLUNTARY EXERCISE ON COGNITIVE PERFORMANCE: ROLE OF SYMPATHETIC NERVOUS SYSTEM ACTIVATION

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#### INTRODUCTION:

Exercise is well known to have beneficial effects including cognitive function. Similar to voluntary exercise, electrical muscle stimulation (EMS) also enhances muscle glucose metabolism. Thus, EMS can be used as an alternative to voluntary exercise. In contrast to exercise, recent studies indicated that acute EMS does not affect cognitive performance. However, it is still unclear why EMS does not affect cognitive performance. The purpose of the present study was to test the specific hypothesis that differential effects of EMS and voluntary exercise are ascribed to the differences in sympathetic nervous system (SNS) activation.

#### METHODS:

Twenty-four healthy male subjects (Age:  $22.5 \pm 1.5$  yr., height:  $172.1 \pm 6.5$  cm, weight:  $67.4 \pm 10.6$  kg) participated in this study. The participants performed Go/No-Go tasks before and after 20 min EMS or voluntary exercise. Reaction time (RT) and accuracy of the task was used to assess cognitive performance. They conducted three types of exercise conditions; EMS condition, heart rate (HR)-matched voluntary exercise, and ratings of perceived exertion (RPE)-matched voluntary exercise conditions. Polar HR monitor was used to measure R-R interval data, and natural log-transformed root mean square of successive differences (LnRMSSD) was calculated to evaluate SNS activity. We



## CP-PN06 Hypoxia and oxygenation

performed two-way analysis of variance with Time and Exercise condition as within-participant factors. Effect size was calculated using Cohen's *d*.

### RESULTS:

We observed a significant main effect of Time on RT, and greater effect was found after RPE-matched exercise relative to EMS and HR-matched exercise. Decrease in LnRMSSD was greater during RPE-matched exercise as compared with EMS and HR-matched exercise ( $p < 0.001$ , respectively). We observed a quadratic relation between cognitive improvement and SNS activation during RPE-matched exercise ( $p = 0.02$ ).

### CONCLUSION:

The present results suggest that cognitive improvement induced by exercise is associated with sympathetic nervous system activation. Given that both central command and exercise pressure reflex increase SNS, the present findings suggest that central command is necessary to improve cognitive improvement induced by acute exercise.

## RELIABILITY OF MUSCLE ARCHITECTURE OF LOWER LIMB MUSCLE VARIES BY MUSCLE, CONTRACTION STATE, AND AGE

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### INTRODUCTION:

Muscle architecture (MA) parameters, such as fascicle length (FL), pennation angle (PA) and muscle thickness (MT), help identify the muscular mechanisms of aging, disuse and exercise. Ultrasonography (US) is often used to assess MA. Reliability of MA outcomes is acceptable for the gastrocnemius medius (GM), tibialis anterior (TA) and vastus lateralis (VL). Interpretation of past reliability data is complicated by a lack of use of adequate statistical methods. For adequate interpretation of reliability results, Intraclass Correlation Coefficients (ICCs) in combination with a measure of absolute reliability, such as the Standard Error of Measurement (SEM) should be used. Also, there is sporadic information about the effects of age and muscle contraction on MA. Therefore, the aim of the current study was to determine intra- and inter-rater reliability of 2-dimensional (2D) US for the GM, TA and VL in young and older adults.

### METHODS:

US scans were collected in 12 young and 12 healthy older adults in rest and during contraction. Three raters scored PA, FL, and MT of US scans 3 times in random order. Intra-rater reliability, reliability between 3 ratings of the same scan, was determined per rater using a single rating ( $k=1$ ), absolute agreement, 2-way mixed model, where ICC is  $(MSR-MSE)/(MSR+(k-1)MSE+k/n(MSC-MSE))$  and SEMs is the square root of MSE. Afterwards, ICCs and SEMs were averaged over the raters. Inter-rater reliability was determined using mean scores of the three ratings ( $k=3$ ), absolute agreement, 2-way mixed effects model, where ICC is  $(MSR-MSE)/(MSR+(MSC-MSE)/n)$  and SEM is the square root of MSE.

### RESULTS:

For intra-rater reliability, ICCs were  $>0.7$  for both groups and conditions, except for the VL PA in the old group ( $ICC_{rest}=0.69$ ,  $ICC_{cont}=0.59$ ). PA SEMs were  $<1.83^\circ$  for both groups and conditions. FL SEMs were  $<0.61$  cm, except for VL (range both groups/conditions: 0.69-1.02 cm). For MW, all SEMs were  $<0.05$  cm, except for VL (range both groups/conditions: 0.07-0.13 cm). For inter-rater reliability, ICCs were  $>0.64$  for both groups and conditions, except for the VL PA and FL of the old group (range both conditions: 0.37–0.55). SEMs of PA were  $<2.9^\circ$  for all parameters. For FL, SEM was  $<0.93$  cm for GM in the young and for TA in both groups. FL SEMs were higher for the GM in the old group ( $SEM_{rest}=1.84$  cm,  $SEM_{contr}=1.03$  cm) and for VL in both groups (Young:  $SEM_{rest}=1.44$  cm,  $SEM_{cont}=2.04$  cm, Old:  $SEM_{rest}=3.95$  cm,  $SEM_{cont}=4.05$ ). MT SEMs were  $<0.17$  cm for both groups and conditions.

### CONCLUSION:

Intra- and inter-rater reliability of US MA is good to excellent for GM and TA muscles at rest and during contraction in both young and old adults. Reliability of US MA measures of the VL is lower and higher absolute errors are expected especially in older people. Overall, it could be stated that reliability of US MA varies by muscle, contraction state and age and this should be taken into account when interpreting MA measures after interventions targeting lower extremity muscles.

## CP-PN06 Hypoxia and oxygenation

### NOCTURNAL OXYGEN SATURATION IS RELATED TO INCREASED URINARY ALPHA-1 ACID GLYCOPROTEIN DURING ASCENT TO 4,800 METRES.

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### INTRODUCTION:

Glomerular proteinuria during ascent to altitude is an established physiologic response, although the mechanisms and relevance to acute mountain sickness (AMS) are unclear. Hypotheses include the degree of hypoxia, acid-base disturbances, and changes in systemic pressure. Recent development of more sensitive approaches to detect glomerular proteinuria, such as urinary alpha-1 acid glycoprotein (a1-AGP) assays, improve the ability to examine this question. To evaluate the effects of hypoxia, acid-base disturbances, and changes in systemic pressure on a1-AGP during ascent the present study aimed to: 1) analyse nocturnal saturation, arterial blood gases, systemic blood pressure, and 24-hour a1-AGP and 2) determine whether a1-AGP results were related AMS.

### METHODS:

Twenty four-hour urine specimens, systolic (SBP) and diastolic blood pressures (DBP) (manual sphygmomanometer), and nocturnal pulse oximetry (WristOx Model 3150, Nonin) were collected at baseline and each day until reaching 4,800 m (12 days/nights), while arterialised blood was collected at baseline and on rest days during the ascent (earlobe samples, analysed via iSTAT blood gas analyser, Abbott). Urine specimens were analysed with an immunoassay developed for low-concentrations of urinary a1-AGP (0.077–148.2mg/L) on the Optilite auto-analyser (The Binding Site, Ltd., Birmingham, UK). AMS was evaluated using the most recent Lake Louise Scoring (LLS) criteria. Statistical analyses were performed using Prism 8 (Graphpad).

### RESULTS:

Twenty-four hour a1-AGP significantly increased with ascent ( $p=0.0002$ ) and was greatest during the first 24-hours at 4,800 m.  $PCO_2$  ( $p<0.0001$ ),  $PO_2$  ( $p<0.0001$ ),  $SaO_2$  ( $p<0.0001$ ),  $HCO_3^-$  ( $p<0.0001$ ), and mean nocturnal  $SpO_2$  ( $p<0.0001$ ) significantly decreased while pH

( $p=0.0173$ ), nocturnal SpO<sub>2</sub> variance ( $p<0.0001$ ), oxygen desaturation index (ODI;  $p<0.0001$ ), and LLS ( $p=0.0091$ ) significantly increased with ascent. Mean 24-hour a1-AGP was correlated with altitude ( $p=0.0003$ ,  $r=0.888$ ), as expected, and also with changes in: LLS ( $p=0.0016$ ,  $r=0.829$ ), SBP ( $p=0.0009$ ,  $r=0.852$ ), PCO<sub>2</sub> ( $p=0.0065$ ,  $r=-0.933$ ), PO<sub>2</sub> ( $p=0.0068$ ,  $r=-0.932$ ), pH ( $p=0.0383$ ,  $r=0.836$ ), tCO<sub>2</sub> ( $p=0.0496$ ,  $r=-0.812$ ), and SaO<sub>2</sub> ( $p=0.0006$ ,  $r=-0.981$ ). Mean 24-hour a1-AGP was also correlated with mean nocturnal SpO<sub>2</sub> ( $p<0.0001$ ,  $r=-0.964$ ), SpO<sub>2</sub> variance ( $p=0.0001$ ,  $r=0.913$ ), and ODI ( $p<0.0001$ ,  $r=0.955$ ).

#### CONCLUSION:

Findings demonstrate that glomerular proteinuria is strongly related to other physiological perturbations that occur during ascent to high altitude, particularly overnight hypoxia. The relationship between 24-hour a1-AGP and nocturnal desaturations at altitude is similar to the relationship seen in persons with sleep apnoea at sea-level. Thus, aspects of sleep at altitude appear to have the greatest effect on a1-AGP which also presents to be novel biomarker of AMS. This evidence provides support for use of urinary a1-AGP and nocturnal pulse oximetry as adjuncts to existing AMS diagnostics during ascent to high altitude.

### APPLICATION OF POST-EXERCISE ISCHEMIA REVEALS AN IMPORTANT ROLE OF PI AND PO<sub>2</sub> IN THE REGULATION OF NRF2 AND NFKB SIGNALLING IN HUMAN SKELETAL MUSCLE

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#### INTRODUCTION:

Exercise-induced signaling is mediated by changes in intracellular Ca<sup>2+</sup>, Pi, H<sup>+</sup>, metabolites, PO<sub>2</sub>, cell energy, and ROS. Nevertheless, it remains unknown which of these plays a predominant role. Ischemia application immediately after maximal exercise traps the accumulation of Pi, metabolites and H<sup>+</sup>, maintaining PO<sub>2</sub> low. One min after exercise with free circulation recovery, Pi and PO<sub>2</sub> are largely recovered. We hypothesized signaling depending on increased Pi and reduced PO<sub>2</sub> will be maintained and that depending on Ca<sup>2+</sup> transients would be reduced during ischemia. To test this, we measured, in muscle biopsies, Nrf2 and NFKB signaling (ROS dependent), and CaMKII (ROS and Ca<sup>2+</sup> dependent), before and after incremental exercise to exhaustion (IE) and post-exercise ischemia.

#### METHODS:

Eleven physically active men performed IE in Normoxia (Nx) and Hypoxia (Hyp) (PIO<sub>2</sub>:73 mmHg). Immediately after IE, the circulation of one leg was instantaneously occluded (300 mmHg). Protein expression (Western Blot) and muscle metabolites were measured in m. vastus lateralis biopsies before (PRE), and 10 (POST, solely occluded leg) and 60s after exercise from the occluded (OC1M) and non-occluded (nOC1M) legs. Blood was sampled from the femoral vein. Statistics: repeated-measures ANOVA.

#### RESULTS:

At POST, muscle lactate increased only at OC1M (25%;  $P<0.05$ ) and PCr was reduced by 94 and 48% in OC1M and nOC1M, respectively ( $P<0.005$ ), similarly in Nx and Hyp. Femoral vein PO<sub>2</sub> was  $21.1\pm 2.0$  and  $10.6\pm 2.8$  mmHg at Wmax, in Nx and Hyp, respectively ( $P<0.001$ ). At POST, pThr286-CaMKII, pSer40-Nrf2, p105-NFkB, and p50-NFkB were elevated, and Keap1 reduced. One min after exercise, Thr286-CaMKII, pSer40-Nrf2, p105 and p50-NFkB and Keap1 remained at POST level in the occluded leg, while they recovered to PRE values in the non-occluded leg. pSer32/36-IkBa was reduced by 29% at POST remaining reduced in OCM1 ( $P<0.01$ ), while it recovered to PRE values in OC1M. Total IkBa was reduced 1min after exercise by 45%, regardless of occlusion. Despite increased protein carbonylation in Hyp, signaling responses were similar in Nx and Hyp ( $P>0.05$ ).

#### CONCLUSION:

This study shows that pThr286-CaMKII, NFkB and Nrf2 signaling pathways are activated during IE to a similar extent in Nx and Hyp. Although femoral vein PO<sub>2</sub> was much lower during IE in Hyp and the oxidative stress higher, the signaling responses were similar in Nx and Hyp. Interestingly, just one min after exercise observed phosphorylations returned to basal, but only when recovery occurred with reperfusion. Furthermore, Keap1 was rapidly resynthesized with free circulation, suggesting that post-exercise biopsies should be taken immediately to capture fast-responding kinases and allosteric regulators. The fact that the occlusion maintained Thr286-CaMKII, Nrf2 and NFkB signaling active suggests that low PO<sub>2</sub> or increased Pi play a critical role in activating and maintaining these signals.

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### CHANGES IN MUSCLE OXYGEN SATURATION DYNAMICS AFTER 8 WEEKS OF TWO VELOCITY-BASED RESISTANCE TRAINING: 20VS40% OF VELOCITY LOSS

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#### INTRODUCTION:

Previous findings have shown that performing 8 repetitions at 60% of 1 RM is correlated with an 82% oxygen saturation lost in the set (1). The 60% of 1 RM load is lifted at 1 m·s<sup>-1</sup> in the squat exercise (2). However, there is a lack of knowledge related to the chronic effect of resistance training in oxygen dynamics using Tissue Oxygenation Index (TOI) as a variable. The aim of the study was to compare two back squat-based resistance training programs (40% vs. 20% of velocity loss) on muscle oxygenation response to a 1 m·s<sup>-1</sup> squat test.

#### METHODS:

A total of 14 young men (20.9±2.6 yrs) were randomly assigned to two groups: 20% of velocity loss (20VL; n=8) and 40% of velocity loss (40VL; n=6). Participants performed an 8-week resistance training-program using barbell back squat exercise controlling mean propulsive velocity (MPV) using a linear transducer position (SmartCoach Power Encoder). The 1 m·s<sup>-1</sup> load test was performed before intervention and the same load was used after training in an 8 repetitions squat test. TOI was measured before and during tests in Vastus Lateralis and Vastus Medialis with a spatially resolved spectroscopy tissue oximeter (NIRO-200Nx). A mixed factorial ANOVA with Bonferroni post hoc comparisons were performed.

#### RESULTS:

No differences were found between groups before and after resistance training programs. Both groups significantly increase the MPV during each repetition of the post-intervention test ( $14.72\pm 3.93\%$  and  $13.27\pm 2.08\%$  for 20VL and 40VL respectively;  $p<0.05$ ). For Vastus Medialis and Vastus Lateralis TOI was reduced in each repetition of the test after intervention in both groups ( $5.28\pm 4.02\%$  and  $5.06\pm 2.97\%$  for 20VL and 40VL respectively;  $p<0.05$ ).

#### CONCLUSION:

Our results showed an increment in MPV with the same load and a decrease in TOI during exercise in both groups after the 8-week resistance training program. This fact shows a greater oxygen intake during back squat exercise in Vastus Medialis and Vastus Lateralis. In conclusion, 8 weeks barbell back squat-based RT program improved strength and muscular tissue oxygen utilization regardless of the velocity loss percentage protocol used.

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**INFLUENCE OF SPRINT DURATION ON MUSCLE ACTIVATION AND PERIPHERAL TISSUE OXYGENATION**

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**INTRODUCTION:**

Sprint interval training (SIT) is typically characterised by short “all-out” repeated sprints interspersed with recovery periods. This training modality can be a time-efficient alternative to traditional aerobic training for bringing about performance and health benefits. Indeed, a growing body of evidence suggests that as few as two sets of 20-s sprints induce training benefits normally associated with traditional aerobic training (e.g. an improved aerobic capacity)<sup>1</sup>. Nevertheless, little is known whether the level of muscular activation or peripheral oxidative metabolism are influenced by sprint duration. Consequently, this study aimed to determine the effects of SIT protocols with different sprint duration on the level of muscle activation and peripheral tissue oxygenation.

**METHODS:**

12 male adults (28.3±4.2 years, 169.9±6.2 cm, 65.6±8.5 kg, peak oxygen uptake: 46.6±8.2 ml/kg/min) participated in the study. They first performed a ramp incremental test to determine peak oxygen uptake. They then performed two 20-s sprints interspersed with 160-s recovery (SIT20) and four 10-s sprints interspersed with 80-s recovery (SIT10) on two separate days in a counterbalanced cross-over manner. T2-weighted magnetic resonance imaging was taken immediately before and after the repeated sprints to determine T2 relaxation time of quadriceps femoris (QF), hamstrings and adductor magnus (ADM) at 50% of right thigh length. Moreover, tissue oxygenation index (TOI) at vastus lateralis (VL) and rectus femoris (RF) were obtained during the sprints via near-infrared spectroscopy. A two-way analysis of variance and independent t-test were performed to compare differences between the SIT protocols.

**RESULTS:**

Both SIT protocols significantly increased T2 values from pre to post in all muscles ( $p < 0.01$ ), and a similar magnitude of increase was observed between the protocols (SIT10 vs. SIT20: QF: 10.9±7.3 vs. 13.0±7.0%; Hamstrings: 8.7±3.1 vs. 8.7±5.7%; ADM: 9.7±4.8 vs. 10.2±6.1%). A significant main effect of condition, and condition by muscle interaction effect ( $p < 0.01$ ) were found in session-averaged  $\Delta$ TOI. It was significantly greater in SIT20 compared with SIT10 in both muscles (SIT10 vs. SIT20: VL: -13.5±5.2 vs. -19.6±6.1%,  $p < 0.01$ ; RF: -12.3±6.2 vs. -22.3±8.5%  $p < 0.01$ ).

**CONCLUSION:**

The changes in T2 relaxation time indicate that sprint duration (i.e. 10s vs. 20s) does not seem to affect the magnitude of muscle activation, provided that total sprint duration and sprint: rest ratio are matched between the protocols. In contrast, greater peripheral oxygen extraction was achieved with SIT20 as indicated by greater  $\Delta$ TOI, suggesting that longer sprints might be more beneficial for improving peripheral oxidative capacity<sup>2</sup>. Future research should explore whether these acute physiological responses are associated with chronic training adaptations (e.g. muscular size or function).

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**TWO BEHAVIORAL PATTERNS OF OXYGENATION AND BLOOD FILLING OF THE VENOUS CAPILLARIES DURING A FATIGUING ISOMETRIC ACTION OF THE BICEPS BRACHII MUSCLE**

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**INTRODUCTION:**

The mechanical pressure of isometric muscle actions might impede the intramuscular capillary blood flow (1-4). Consequently, the oxygen saturation and the blood filling of vessels could be affected. However, the behavior of these parameters during that type of muscular activity is still not understood entirely (5). The objective of the present study was to describe the behavior of the capillary-venous oxygen saturation of hemoglobin (SvO<sub>2</sub>) and relative hemoglobin amount (rHb), which is an indicator of blood filling, during a fatiguing isometric muscle action.

**METHODS:**

7 male and 3 female subjects (mean age ±SD = 28.6 ±11.68 years) were measured during one fatiguing isometric muscle action of the biceps brachii by use of the O2C spectrophotometer (Oxygen To See; LEA Medizintechnik GmbH, Gießen, Germany). The probe was stuck above the belly of the biceps brachii muscle. A weight of 60% of the maximal voluntary isometric contraction was applied via a cuff 2,5 cm proximal to the wrist crease and had to be hold as long as possible in a 90° elbow flexion. The weight was taken off as soon as the angle of the elbow exceeded the 90° for more than two seconds. The subsequent recovery phase in a resting position was recorded, too.

**RESULTS:**

Two behavioral patterns (type I and type II) emerged. Despite a general decrease and leveling off into a steady state of SvO<sub>2</sub>, type II showed a significantly deeper deoxygenation (-33.86±17.35 pp,  $p = .008$ ) than type I (-10.37 ±2.59 pp). Another difference was the behavior of rHb. While in type I it behaved nearly parallel to SvO<sub>2</sub> with a positive rank correlation ( $\rho = 0.735$ ,  $p < .001$ ), a partial opposing behavior ( $\rho = -0.522$ ,  $p < .001$ ) occurred in type II. First rHb decreased until a reversal point, then increased averagely 13% above the baseline value and leveled off into a steady state.

During recovery, both parameters in both types reset to or increased above the baseline value, albeit after an initial decrease of rHb until a second reversal point in type II.

**CONCLUSION:**

The results suggest that two types of regulation of the oxygenation and blood filling can be described during a fatiguing isometric muscle action. Despite of a relatively high intramuscular pressure, the steady states reveal that a homeostasis of oxygen delivery and consumption in the capillary system is possible. For an explanation of the two types, a trigger mechanism of the blood filling (rHb) depending on the oxygenation level is hypothesized.

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### THE IMPACT OF THREE CONSECUTIVE DAYS OF ENDURANCE TRAINING IN HYPOXIA ON MUSCLE DAMAGE, INFLAMMATORY AND PERFORMANCE RESPONSES.

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#### INTRODUCTION:

Training in hypoxia (hypoxic training) has been widely utilized to improve endurance capacity (Dufour et al. 2005). However, the influence of the training in hypoxia on muscle damage, inflammatory and performance responses remains unclear. These information would be great help to prevent overtraining syndrome during hypoxia training. The purpose of the present study was to determine the effect of three consecutive days of endurance training in hypoxia on muscle damage, inflammatory and performance responses.

#### METHODS:

Nine active healthy males completed two trials on different period, consisting of either three consecutive days of endurance training in hypoxia (FiO<sub>2</sub>: 14.5%, HYP) or normoxia (FiO<sub>2</sub>: 20.9%, NOR). They performed daily 90-min sessions of endurance training consisting of high-intensity endurance interval pedaling (10 × 4 min pedaling at 80% of VO<sub>2</sub>max with 2 min of active rest at 30% of VO<sub>2</sub>max) followed by 30 min continuous pedaling at 60% of VO<sub>2</sub>max during three consecutive days (days 1-3). The pedaling workloads during endurance training were relatively matched for VO<sub>2</sub>max in hypoxia or normoxia. Venous blood variables, muscle function of lower limb, local bio-impedance (as an indication of muscle swelling) of vastus lateralis muscle (VL), subjective feelings of fatigue and muscle soreness were determined in every morning during experimental period (days 1-4) to evaluate the muscle damage and inflammation. On day 4, subjects performed an incremental exercise test (IET) to evaluate performance response.

#### RESULTS:

Pedaling workload during endurance training was significantly lower in the HYP (interval exercise: 166 ± 4 W) than in the NOR (194 ± 8 W, P < 0.0001). Serum creatine kinase and high-sensitive C-reactive protein concentrations did not change significantly during training period in either trial. Maximal voluntary contraction of knee extension (P < 0.0001) and drop jump index (P = 0.004) were decreased significantly with training in both trials, with no significant difference between the two trials. The local bio-impedance of VL reduced (an indication of augmented muscle swelling) significantly on day 3 and day 4 in both trials (P < 0.0001), whereas no significant difference was observed between the two trials. The scores of muscle soreness and fatigue increased significantly in both trials (P < 0.0001). However, HYP involved significantly lower score of fatigue on day 4 compared with NOR (P = 0.004). Blood lactate concentrations and maximal aerobic power output during IET did not differ significantly between the two trials.

#### CONCLUSION:

Three consecutive days of endurance training in hypoxia induced similar levels of muscle damage, inflammatory and performance responses compared with the same training in normoxia.

## CP-PN07 Sex differences: Physiology and biomechanics

### A SEX-SPECIFIC EVALUATION OF THE EFFECTS OF AN AEROBIC INTERVAL TRAINING CARDIAC REHABILITATION PROGRAM ON PHYSICAL AND MENTAL HEALTH IN ADULTS WITH CARDIOVASCULAR DISEASE

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#### INTRODUCTION:

Notwithstanding the well-known benefits of cardiac rehabilitation (CR), it remains underutilized, particularly among women. Aerobic interval training (AIT) is an emerging exercise training paradigm that may address frequently cited barriers to traditional CR (e.g. lack of motivation/enjoyment and time). Sex-specific evaluations of AIT in CR are scarce. We compared the impact of AIT on physical and mental health outcomes between women and men with cardiovascular disease and examined their perspectives of such programming (e.g. favourite components, suggested improvements).

#### METHODS:

This was a pre-post mixed-methods study. Patients attended an on-site AIT CR (10-minute warm-up, 25 minutes of interspersed higher- [4 min at 85-95% heart rate (HR) peak] and lower- [3 min at 60-70% HR peak] intensity intervals, 10-minute cool-down) twice weekly for 10 weeks. Body mass index (BMI); waist circumference (WC); resting blood pressure (BP); cardiometabolic biomarkers; peak aerobic power (VO<sub>2</sub>peak) estimated from a graded exercise treadmill test; and, depression and anxiety levels measured by the Hospital Anxiety and Depression Scale were collected at baseline and follow-up. Patients' satisfaction was captured using a feedback questionnaire. Independent t-tests and Mann-Whitney U tests were used to compare sex-differences in physical and mental health at baseline. Analyses of covariance were used to compare sex specific changes from baseline to follow-up. Chi-square analyses were used to examine sex-differences in program completion.

#### RESULTS:

A total of 162 participants (33% women, 57±10 years) attended the AIT program. At baseline, women compared to men had lower WC (91.6±13.6 vs. 100.1±10.7 cm, p<0.001) and VO<sub>2</sub>peak (27.8±6.2 vs. 34.6±6.2 mL/kg/min, p<0.001); and, higher total cholesterol (4.2±1.2 vs. 3.2±0.7 mmol/L, p<0.001), high-density lipoprotein (1.5±0.4 vs. 1.1±0.3 mmol/L, p<0.001) and low-density lipoprotein (2.2±1.0 vs. 1.5±0.6 mmol/L, p<0.001). Women demonstrated a smaller increase in VO<sub>2</sub>peak than men (2.0±2.9 vs. 3.0±4.0 mL/kg/min, p=0.006) following AIT.

No differences were observed for changes in BMI ( $-0.2 \pm 1.1$  vs.  $-0.3 \pm 1.4$  kg/m<sup>2</sup>), WC ( $-2.7 \pm 5.5$  vs.  $-2.0 \pm 4.2$  cm), BP ( $4/0 \pm 17/9$  vs.  $1/-1 \pm 14/9$  mmHg), anxiety ( $-1.4 \pm 3.4$  vs.  $-1.2 \pm 2.9$  points) or depression ( $-0.6 \pm 2.8$  vs.  $-0.9 \pm 2.7$  points) between women and men. Participants enjoyed the: varying exercise intensities of AIT, individualized approach, group format, enthusiastic staff and HR monitoring. More women withdrew from the program than men (18.9% vs. 7.3% dropout,  $p=0.028$ ), but women and men attended a similar number of sessions ( $15 \pm 7$  and  $17 \pm 6$  out of the 20 exercise sessions prescribed,  $p=0.085$ ).

**CONCLUSION:**

AIT led to clinically meaningful improvements in  $\dot{V}O_{2peak}$  in both sexes; women experienced a significantly smaller increase in  $\dot{V}O_{2peak}$  than men. Changes in anxiety and depression did not reach clinical significance ( $<1.7$  points). Larger CR trials enrolling a greater proportion of women are needed to confirm these findings.

**SEX COMPARISONS OF THE SINGLE-LEG LANDING TASK**

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**INTRODUCTION:**

Females have a higher incidence of anterior cruciate ligament (ACL) injury than males [1]. The current screening tools for the ACL injury tend to focus on landing tasks, such as the double-leg landing error scoring system (LESS) [2]. However, sports specific demands do not merely require the double-leg landing skills. Therefore, the development of a single-leg landing screening tool to detect sex differences in movement quality may be warranted. This study aimed at investigating sex differences in the single-leg landing task.

**METHODS:**

30 collaged male athletes and 24 collaged female athletes without a current lower extremity orthopedic injury or history of lower extremity surgery were recruited. All participants completed 3 trials of a single-leg landing task on both limbs that were recorded by three video cameras. Each single-leg landing task was scored for errors by a single rater. The intra-rater reliability and precision were good (ICC<sub>2,3</sub> ± SEM =  $0.89 \pm 0.6$ ). The single-leg landing error scoring task rubric has 13 items which were modified from the double-leg landing error scoring system (17 items). Independent T-tests were performed to examine the differences of the single-leg landing errors between males and females.

**RESULTS:**

Female athletes displayed a greater number of total single-leg landing errors than males on the right limb ( $8.6 \pm 1.1$  Vs  $7.9 \pm 1.3$ ,  $p=.030$ ). There was a significant difference of the subscore error in knee flexion at initial contact on the right limb between females and males ( $1.0 \pm 0.1$  Vs  $0.8 \pm 0.4$ ,  $p=.022$ ). On the left limb, females also showed higher total single-leg landing errors than male athletes ( $9.1 \pm 1.4$  Vs  $8.1 \pm 1.3$ ,  $p=.009$ ). There was a significant difference of subscore error in hip flexion at initial contact ( $0.9 \pm 0.2$  Vs  $0.8 \pm 0.2$ ,  $p=.046$ ) and in hip flexion displacement ( $0.9 \pm 0.2$  Vs  $0.8 \pm 0.4$ ,  $p=.046$ ) on the left limb.

**CONCLUSION:**

Female athletes displayed worse total single-leg landing scores on both limbs than male athletes. At initial landing, females were more likely to land with a straight knee on the right side and to land with an extended hip on the left side than males. This works suggests that sex disparity and limb asymmetric movement strategies exist at landing. Future research is required to determine if the single-leg landing error scoring task could be a screening tool for ACL injury.

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**THE EFFECT OF SEX ON GROUND REACTION FORCE PARAMETERS DURING RUNNING, INFLUENCES OF RUNNING SPEED AND ANTHROPOMETRICS.**

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**INTRODUCTION:**

Ground reaction force (GRF) is a key parameter to study running mechanics. Previous studies which assessed the effect of sex did not control for major factors also influencing GRF like speed or anthropometrics. The purpose of the study was to investigate the running GRF differences between male and female while controlling for other potential covariates. We hypothesized that the main sex effect on GRF would be largely reduced while controlling for speed, height, weight and fat mass proportion.

**METHODS:**

The dataset was taken from a previous randomized trial on the influence of footwear cushioning and runners' body mass on running-related injuries (Malisoux et al. 2017). During the inclusion sessions, 874 participants (337 females) performed a running test on an instrumented treadmill, which consisted of a 3-minute warm-up, followed by 10 minutes at the self-declared preferred running speed. Step frequency (SF) and length (SL), contact (CT) and flight times (FT), duty factor (DF), impact (IPF) and active peaks (APF), loading rate (LR), vertical oscillation (VO), leg (KL) and vertical stiffness (KV) were calculated and averaged over the last 2 minutes of the running bouts for each participant. Simple ANOVAs with sex main effect were first performed on each GRF parameters. In a second model, speed was included in the ANCOVA as a covariate factor. Finally, a third model with additional anthropometrics covariates (i.e. height, weight and fat mass proportion) was performed. Partial omega square values ( $\omega^2$ ) were used for effect size analyses, with  $\omega^2 > 0.01$ , 0.06 and 0.14 indicating small, moderate and large effects respectively.

**RESULTS:**

Simple ANOVAs revealed small effects of sex on CT, FT, KL and KV, moderate effects on DF, IPF, APF, LR and VO, and large effects on SL ( $p<0.001$ ). In the second model, only small effects of sex were observed on SF, SL, CT, DF, IPF, VO and KV ( $p<0.001$ ). In this model, speed showed small effects on VO and KL, moderate effects on SF and FT and large effects on SL, CT, DF, IPF, APF, LR and KV ( $p<0.001$ ). In the third model with speed and anthropometrics covariates, no sex effect was reported ( $p>0.05$ , while speed presented small effect on FT, moderate effects on SF, IPF and KL and large effects on SL, CT, DF, APF, LR and KV ( $p<0.001$ ). Height presented small effects on CT, FT, IPF and VO and moderate effects on SF, SL and KV ( $p<0.002$ ). Weight did not present any significant effect ( $p>0.05$ ), while fat mass proportion presented small effects on CT, FT, DF, APF, VO and KL ( $p<0.001$ ).

**CONCLUSION:**

Crude sex differences observed in running GRF were mainly due to running speed and anthropometrics differences between male and female runners. Among anthropometrics, height and fat mass proportion seem to have an important influence on GRF parameters. The highlighted covariations should be taken into account for future studies on running GRF.

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**ANTHROPOMETRIC AND PHYSIOLOGICAL DIFFERENCES BETWEEN MALE AND FEMALE ROW CREWS - "TRAINERAS"**

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**INTRODUCTION:**

Anthropometric, physiological and performance differences between rowers of the same club competing in different categories have been observed in the rowing of traineras (fixed bank) (Izquierdo Gabarren, et al., 2010). Maximum aerobic power has been defined as one of the best predictors of rowing performance (Perkins & Pivarnik, 2003). The aim of this study was to observe gender differences between rowers in anthropometric, physiological and aerobic power data.

**METHODS:**

55 subjects of a Northern Spain rowing club were evaluated for weight (P), size (T), fat percentage (G), six-fold sum (S6) and absolute (W) and relative watts (W/kg). Within the 55 subjects, 38 were men ( $26.9 \pm 7$  years old) and 17 women ( $24.8 \pm 6.8$  years old).

**RESULTS:**

Sample means were calculated by gender in the variables analyzed (F: female and M: male). The results were as follow: M: [P: 77,25 (9,41) – T: 1,80 (0,07) – G: 12,77 (3,04) – S6: 72,23 (28,20) – W: 273,6 (52,88) – W/kg: 3,57 (0,67)]; F: [P: 61,79 (6,85 – T: 1,67 (0,07) – G: 14,44 (2,47) – S6: 103,83 (28,64) – W: 171,35 (29,19) – W/kg: 2,78 (0,43)]. To calculate the size of the effect as a difference of standardized means, Cohen d was used. Findings were as follows: P: 1,90 – T: 1,86 – G: 0,61 – S6: 1,11 – W: 2,49 – W/kg: 1,44.

**CONCLUSION:**

A large effect size has been observed after analyzing the results obtained by Cohen d between genders in all the variables analyzed, excluding the fat percentage variable. Further research is suggested on the comparison of values between men and women in the sport of traineras. The data in this study suggest that a review and potential improvement of the female trainera is needed, based on the female rowers physiological and anthropometrics needs.

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**THE EFFECTS OF THE GOOD POSTURE SPINAL EXERCISE PROGRAM USING SNPE BELT ON BODILY CHANGES IN ADOLESCENTS: GENDER DIFFERENCES.**

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**INTRODUCTION:**

Postural abnormalities in adolescents may affect long-term health. Early detection of poor posture and correction during adolescence is very important for numerous reasons, including facilitating proper physical growth, reducing the risk of musculoskeletal pain and fatigue. It is well known that physical growth in adolescents differs between genders; however, there are few studies which consider these gender differences. The aim of this study was to compare the effects of the Good Posture Spinal Exercise (GPSE) with and without the SNPE (Self Natural Posture Exercise) belt in adolescents and to determine sex-specific associations.

**METHODS:**

A total of 90 middle school students were divided into exercise groups (GPSE) with the SNPE belt (EXP1: 12 males and 16 females), GPSE without the SNPE belt (EXP2: 12 males and 20 females), and a control group (CON: 12 males and 18 females). Subjects in the EXP1 and EXP2 groups underwent a 12 week GPSE program (2 times/week, 60 mins/session). Nine different postures and the body composition of all study participants were evaluated using the SNPE posture measuring app and Inbody Body Composition Analysis machine. Paired sample t-test and one-way measured ANOVA were performed, and significant main effects were followed by Scheffe and Dunnett T3 post-hoc procedures.

**RESULTS:**

Significant differences were found in both experimental groups after the GPSE program. In females, these differences included 6 of 9 postures ( $F=3.63\sim 16.44$ ,  $p<0.05$ ), muscle mass ( $F=13.56$ ,  $p<0.001$ ), and body weight ( $F=4.98$ ,  $p<0.001$ ). In males, differences included 2 of 9 postures ( $F=8.688$  and  $7.414$ ,  $p<0.01$ ) and body weight ( $F=4.976$ ,  $p<0.05$ ). Significant differences were also found between the experimental groups, and varied by gender. Females in EXP1 showed differences in 7 of 9 postures, muscle mass, and body fat percentage while those in EXP2 had differences in 8 of 9 postures, muscle mass, body fat percentage, and body weight ( $P<0.05$ ). Males in EXP1 showed significant differences in 8 of 9 postures, muscle mass, body fat percentage, and body weight while males in EXP2 had differences only in 4 of 9 postures and muscle mass ( $P<0.05$ ).

**CONCLUSION:**

This study demonstrated 12 weeks of GPSE programming improved posture and body composition in both male and female adolescents. These results suggest that incorporating SNPE belts into GPSE programming improves the benefits for male adolescents. Further clinical trials are required to determine if the gender differences seen using the SNPE belt are based on gender, or other unanalyzed factors such as the severity of the problematic posture.

\*This research is part of the dissertation of Dr. Choi: The Effects of the Good Posture Spinal Exercise Program Using SNPE Belt in Bodily Changes for Adolescents: An Intervention, Pacific Inter Continental College, 2018, Philippines

## CP-PN08 Inflammation

### EFFECT OF AEROBIC AND RESISTANCE EXERCISE ON ENDOPLASMIC RETICULUM STRESS AND INFLAMMATION IN ADIPOSE OF OBESE RATS

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#### INTRODUCTION:

Inflammation of adipose tissue is an important factor in inducing various obesity-related diseases. The endoplasmic reticulum stress (ERS) may be a core mechanism to link obesity, chronic inflammation, and peripheral insulin resistance. In order to decrease the ER protein load, UPR drives to the upregulation ER-chaperones, such as glucose-regulated proteins78 (GRP78), to promote protein refolding. Moreover, UPR leads to the downregulation of protein translation through the activation of stress sensors such as protein kinase R-like ER kinase (PERK), inositol-requiring enzyme (IRE1) and activating transcription factor(ATF6). Appropriate exercise is an effective way to prevent obesity.

#### METHODS:

Sprague-Dawley rats were randomly assigned to three groups: control group(OC), aerobic exercise group(OA), resistance exercise group(OR). The rats of OA group performed treadmill exercise, speed increase from 15m/min to 28m/min, and the time increased from 20min to 60 min during 8 weeks, training were performed 5 days per week. The rats in OR group were allowed to climb a vertical ladder with progressively increased weights, sessions were performed one time per three days for 8 weeks. Then bilateral inguinal fat(in-WAT) and epididymal fat(ep-WAT) were isolated at 48h after the last exercise section. The Quantitative Real-time PCR was used to detect the mRNA expression of genes and Western Blot was used to detect the proteins about ERS and inflammation.

#### RESULTS:

After 8-week exercise, the average body mass and the weight of in-WAT and ep-WAT of the OA and OR groups were significantly lower than the OC group; The mRNA expression of GRP78 and IRE1, and the protein expression of GRP78 and p-IRE1/IRE1 of OA group were significantly lower than OC group both in in-WAT and ep-WAT, but there were no differences of ATF6 and PERK between OA group and OC group neither mRNA nor protein expression. There were significantly different of mRNA expression of PERK in ep-WAT and IRE1 in in-WAT and the protein expression of p-IRE1/IRE1 in in-WAT between OR and OC group. The mRNA and protein expression of IL-6 and TNF- $\alpha$  of OA group were significantly lower than OC group in both two WATs, except the protein expression of TNF- $\alpha$  in ep-WAT. The mRNA expression of IL-6 of OR group was significantly higher than OC group in both two WATs and TNF- $\alpha$  mRNA expression was higher in in-WAT.

#### CONCLUSION:

Most studies have shown that aerobic exercise can effectively reduce the occurrence of ER stress, which is consistent with the results of this study. In this study, resistance exercise increased the ERS and inflammation, which is contrary to the current results, possibly due to different exercise intensity. We found that under the stimulation of exercise on adipose tissue, the IRE1 signaling pathway was activated while the other two pathways were not activated, which may indicate that the IRE1 signaling pathway may be more closely related to the exercise than PERK and ATF6 signaling pathways.

### BIOCHEMICAL AND MOLECULAR TISSUE RESPONSE AFTER AEROBIC AND ANAEROBIC EXERCISE – TISSUE CONTENT CHANGES

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#### INTRODUCTION:

Adaptation mechanisms against soft tissue injuries and accelerating recovery time after different type of exercise are still poorly understood and biomarkers for that still need to be established. Recent years brought the era of cell-free DNA (cfDNA) as a potential biomarker of the injury level, which is gaining an interest in many various biomedical disciplines, including the field of exercise physiology. The aim of this study was to evaluate the usage of cfDNA in a comparison to well-known and used biochemical inflammatory markers in the assessment of exercise-induced tissue damage. Furthermore we wanted to show the differences of such response in a correlation to various tissue content (muscle, fatty tissue).

#### METHODS:

Three populations were analyzed: twenty three well trained man with high concentration of muscle tissue (PAM) aged 20.2 $\pm$ 1.2 years, 18 physically non-active men with higher BMI and fatty tissue concentration (PNAM) aged 19.9 $\pm$ 1.0 years and 15 non-training man with normal BMI and fatty tissue concentration aged 20.1 $\pm$ 1.7 years. All of them performed lower body 30s Wingate Tests and Bruce test to measure maximal anaerobic and aerobic capacity. Blood for biochemical analysis for Want and Bruce testing was collected in six time-points (in the morning just before the test and up to 5 min, 30 min, 1h, 6h, 24 hours after testing). Biochemical analysis was performed on the Luminox xMAP instrument. For cfDNA analysis blood was collected in four time-points: before physical exercise (in the morning just before the test), up to 5 minutes, 30 minutes and 60 minutes post-exercise. cfDNA concentration was measured using fluorometric method.

#### RESULTS:

A significant time effect characterizing an inflammatory state (pre vs post) following the exercise bout in all conditions ( $p < 0.05$ ) was observed. IL-1, IL-10 and IL-6 show a direct relationship with the body fat content. Besides, a significant change in cfDNA concentration was observed. Overall, the results indicate that the reduction of inflammatory process is correlated with cfDNA change and both - molecular and biochemical response – show a direct tissue dependence.

#### CONCLUSION:

cfDNA can be used as a biomarker of exercise-induced inflammatory process in an aerobic and anaerobic condition and show a great potential in evaluation of exercise load. Differences in tissue content correlate with the severity of inflammatory responses.

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**THE ACUTE EFFECT OF TWO TYPES OF EXERCISE (ENDURANCE AND PLYOMETRIC) ON SA-KI LEVELS IN HEALTHY AND TRAINED MEN.**

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**INTRODUCTION:**

Klotho protein was discovered two decades ago in a strain of mutated mice. Kuro-o and collaborators suggested that the levels of this protein could be related to aging process (1). Recently, a direct relationship between physical condition and Klotho levels has been found. Some studies suggest that Klotho would have an acute response to endurance exercise, raising its levels just after the session (2,3). Nevertheless, the literature dedicated to this area is still scarce, and even more in relation to strength exercise, one study stating that Klotho does not have an immediate response to this type of exercise (4). For this reason, we consider relevant our following. **OBJECTIVE:** to analyze the acute effect of two types of exercise (endurance and strength) on the values of Sα-KI in healthy trained men.

**METHODS:**

85 healthy trained men (30±9yrs.) with VO<sub>2</sub>max of 56,9±5,05ml/kg/min measured by incremental test on treadmill were divided into two groups: i)Endurance Acute Exercise (EAE) (N=46) and ii)Plyometric Acute Exercise (PAE) (N=39) Their body composition was analyzed by Dual Densitometry X-Ray, 2 blood samples by venipuncture were taken for both groups: PRE and POST exercise session. The exercise sessions consisted in EAE: running in treadmill at 75% of their VO<sub>2</sub>max for 45 minutes and PAE: 5 sets of 20 jumps from a 60cm drawer followed by plyometric phase, with 2 minute rest between sets and 10 second intervals between jumps and with 10% of their additional body weight added with dumbbells. The serum SαKI levels were measured by enzyme-linked immunosorbent assay (ELISA) in pg/mL. For the statistical analysis was used SPSS 19.1 Software.

**RESULTS:**

We found statistically significant interaction time per group between EAE group (PRE: 1079,06±492,4pg/mL; POST: 1203,36±302,15pg/mL) vs PAE group (PRE: 1058,3±250,1pg/mL; POST: 1001,97±231,78pg/mL) (p=0.010; η<sup>2</sup>=0.08).

**CONCLUSION:**

The results show that EAE triggers an acute effect increasing the SαKI levels as soon as the session is over according to Mostafidi et al (2). However, this effect does not seem to happen with the PAE group, where Sα-KI levels decrease after exercise, coinciding with the findings of Saghiv et al. (4). It is known that the inflammatory process occurs up to 24 or 48 hours after a strength session (5), this could explain why Sα-KI, who is directly linked to the inflammatory processes (6), does not present an immediate acute effect. Further studies would be necessary in order to study the kinetics of this biomarker to better understand its behavior.

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**CP-PN09 Molecular biology and biochemistry****EXERCISE, MORE THAN A LOW CARBOHYDRATE DIET, AFFECTS DIFFERENTIAL COUNT, HOMING AND PROLIFERATION RATE OF IMMUNE CELLS: A RANDOMISED CROSS-OVER TRIAL.**

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**INTRODUCTION:**

Low carbohydrate (LC) diets are gaining popularity amongst athletes because of their suggested performance enhancing properties. However, the impact of such a diet on the exercise-induced immune response is unclear. Therefore, we investigated the effects of a LC diet on the exercise-induced immune response.

**METHODS:**

In this cross-over study, fourteen well-trained male athletes (32.9±8.2 years, VO<sub>2</sub>max 57.3±5.8 ml/kg/min) followed for two weeks a LC diet (<10En% CHO) and for two weeks a high carbohydrate (HC) diet (>50En% CHO), in random order, with a wash-out period of >2 weeks in between. After 2 days and 2 weeks on each of the diets, participants cycled for 90min at 60% Wmax. Blood samples for cortisol, immune cell differential count, proliferation, and homing markers were collected at different time points before and after exercise.

**RESULTS:**

Two days adherence to the LC diet resulted in a strong exercise-induced stress response as reflected by an 81% increase of serum cortisol levels, compared to a modest ~20-30% at the other three occasions.

A clear exercise-induced response was observed for immune cell differential count, proliferation, and homing markers. Baseline cell differential counts were comparable between diets. Directly after exercise cell differential count was significantly different between diets after 2 days adherence, with higher T cell and Th cell counts on the HC diet (p<0.05). Two hours post-exercise, T cell, Th cell and B cell counts were higher on the HC diet after 2 days adherence (p<0.05) and monocyte count was higher on the LC diet (p=0.016). After 2 weeks adherence to the diets cell counts were comparable between diets at all time points (p>0.05).

The HC diet resulted in a significant decrease in cell proliferation rate from directly post-exercise till 2 hours post-exercise (p=0.024 after 2 days and p=0.015 after 2 weeks diet), while the LC diet did not. Finally, Th cell airway homing was lower after 2 days adherence to the LC diet compared to the HC diet at 2 hours post-exercise (p=0.038), with no differences after 2 weeks adherence.

**CONCLUSION:**

After 2 days adherence to the diets, both the stress and immune response were different between the low-carbohydrate and the high carbohydrate diet. These differences were no longer observed after 2 weeks adherence to the diets. Both the stress and immune response were more pronounced after 2 days on the diets compared to 2 weeks on the diets. Exercise seems to dictate the immune response, while diet was of less influence.



### DEVELOPMENT OF NOVEL MUSCLE FUNCTION EVALUATION METHODS FOR DUCHENNE MUSCULAR DYSTROPHY (DMD) MODEL MICE AFTER CELL THERAPY

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#### INTRODUCTION:

Duchenne muscular dystrophy (DMD) is characterized by the progressive degeneration and fragility of skeletal muscles. It is caused by mutation to the DMD gene, responsible for coding the dystrophin protein that surrounds myofibers. We are currently developing cell therapy as a future curative treatment for DMD. So far, we have succeeded in transplanting immortalized human myoblast cells (Hu5/KD3) (1) in the muscles of an immunodeficient DMD mouse model (DMD-null/NSG) (2). These cell transplantations showed the potential to restore dystrophin in their muscles; however, their functional recovery still seems to be insufficient. We are now aiming to accurately evaluate the DMD model-mouse muscle function in order to evaluate the therapeutic effects of cell transplantations more precisely.

#### METHODS:

We have been focusing on the decline of muscle contraction force by evaluating the maximal contraction forces ratio before and after different types of training. First, repetitive electrically-stimulated isometric contractions have been conducted on the mice gastrocnemius muscles. Different numbers of contractions (1 to 50), loads (10%, 40%, 100% of the maximal contraction force) and frequencies (1s, 10s, 30s) have been tested to find the most appropriate evaluation method for DMD muscles. Secondly, we have been interested in treadmill running which has the advantage to be more functional for clinical application. Different parameters have also been tested as speed (5m/min, 9m/min, 12m/min) and duration (15min, 30min) on flat course. Finally, these experiments have been conducted at different ages, from 9wo to 37wo, to confirm the progress state of the disease with aging.

#### RESULTS:

The 50 repetitions of electrically-stimulated isometric contractions at 10% and 40% of the maximal contraction force have successfully characterized the DMD phenotype of the model-mice from 9wo to 25wo, in comparison to wild type mice. The 15min treadmill flat running test, at 9m/min or less, has shown important differences concerning the decline of muscle strength between DMD and wild type mice.

#### CONCLUSION:

Repetitive isometric contractions and treadmill running with defined parameters have both shown their advantages for the evaluation of DMD mice muscle function. Our current plans are now to repeat these experiments adding a Hu5/KD3 cells-transplanted DMD mice group. Thus, our study will provide an accurate evaluation approach for DMD patients when the cell therapy goes to clinical trials.

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### THE EFFECTS OF MESENCHYMAL STEM CELLS INJECTION AND ACUTE RESISTANCE EXERCISE ON BASAL MUSCLE PROTEIN METABOLISM IN MOUSE SKELETAL MUSCLE

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#### INTRODUCTION:

Aging dependent declines in skeletal muscle mass, strength and quality (sarcopenia) are leads to not only physical disability but are also related to metabolic complications. Mesenchymal stem cells (MSCs) are multipotent cells and have been reported to accumulate to inflamed site and regenerating skeletal muscle tissue. These adaptations are further supported by its differentiation potency into skeletal muscle cells and secretional capacity of variety of growth factors (e.g., insulin like growth factor 1), all of which implicate MSCs' potency to prevent and/or treat sarcopenia (1, 2). Resistance exercise (RE) is another countermeasure for the prevention of sarcopenia, and is known to cause minute injury and inflammation in exercised muscle (3). Therefore, RE may enhance muscle growth effect of MSCs. The present study aimed to investigate the effect of intramuscular injection of MSCs and acute RE on muscle protein synthesis and related signals and additive effect in mouse skeletal muscle.

#### METHODS:

Male C57BL/6J mice were divided into MSC group (N = 5) and MSC + RE group (N = 5). Mice were intramuscularly injected with green fluorescence protein (GFP) labeled with either MSCs ( $2.0 \times 10^6$  cells suspended in 30  $\mu$ L PBS) or vehicle only placebo into right gastrocnemius muscle under isoflurane anesthesia. Left gastrocnemius muscle in each group was injected with only the vehicle and served as the control. Just before the injection, single bout of RE (consists of 3s  $\times$  10 reps  $\times$  5 sets maximal isometric contraction, elicited by transcutaneous electrical stimulation) was performed on the right gastrocnemius muscle in MSC + RE group. Seven days after the injection, muscle samples were collected, and muscle protein synthesis was measured by SUNSET method.

#### RESULTS:

GFP was expressed only in MSCs-injected muscles, but the amount was not affected by RE. Injection of MSCs or RE did not enhance muscle protein synthesis. The expression of phosphorylated Akt (Ser473) was not increased, but that of total Akt was increased by injection of MSCs (main effect of MSC,  $P < 0.0001$ ). On the other hand, injection of MSCs increased expressions of phosphorylated p70S6K (Thr389), rpS6 (Ser240/244), 4EBP1 (Thr37/46) and total rpS6 in non-exercised leg, but the phosphorylation status were not enhanced by a prior bout of RE (main effect of MSC,  $P < 0.01$ ,  $P < 0.0001$ ,  $P < 0.01$ ,  $P < 0.0001$ , respectively). Total expressions of p70S6K and  $\gamma$  form ratio of total 4EBP1 were not affected by injection of MSCs or RE.

#### CONCLUSION:

The present results suggest that injection of MSCs does not activate protein synthesis but may enhance mechanistic target of rapamycin complex 1 (mTORC1) activities at basal state. On the contrary, single bout of RE did not further augment MSCs-induced mTORC1 activity.

## THE EFFECT OF COLLAGEN (COL3A1, COL5A1, COL12A1) GENES VARIANTS ON PHYSICAL PERFORMANCE PHENOTYPE IN LITHUANIAN ELITE ATHLETES

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### INTRODUCTION:

Collagens are one of the most important structural proteins in human. Genetic variants within the alpha chains of the collagens type I (COL1A1), type III (COL3A1) and XII (COL12A1) genes have been associated with physical performance and risk of musculoskeletal injuries. The aim of this case-control association study was to investigate collagen genes variants (COL1A1 C>A, rs1800012; G>T, rs1107946; COL3A1 G>A, rs1800255, COL12A1 T>C, rs970547) in Lithuanian elite athletes.

### METHODS:

A total of 185 athletes (endurance-oriented (n=66), sprint/power-oriented (n=80) and mixed (footballers, n = 39) groups, and 195 non-athletes controls from Lithuania were genotyped by RT-PCR. The phenotypic variables included: data of injury, anthropometric and functional capacity measurements.

### RESULTS:

Analysis of phenotypic data showed that anaerobic power indexes (e.g. stair-climb test etc.) were higher in the sprint/power group of athletes compared to the endurance group. Of all sports groups, footballers was the most injured (~80% of these injuries involved the lower leg, knee, ankle, or foot). The results of phenotype-genotype association analysis were not statistically significant, but there were visible tendencies: athletes with particular genotype were more likely to have some injuries than other ones (45% of athletes with COL1A1 rs1800012 GG genotype, 61% with COL1A1 rs1107946 CC genotype, 71% – COL3A1 rs1800255 GA genotype, and 61% –COL12A1 rs970547 TT genotype experienced injuries). The distribution of genotype frequencies of COL1A1 rs1800012 variant in the whole athletes group significantly differed from the controls (CC/CA/AA: 74.1/17.3/8.6% vs 65.6/28.2/6.2%; p=0.035). In sprint/power group the COL1A1 rs1107946 rare A allele (28.9 vs 16.4%, p=0.001) and COL12A1 rs970547 common T allele (83.1 vs 74.6%, p=0.041) were significantly more frequent than in controls. In the female group of sprint/power-oriented sports the COL1A1 rs1800012 C allele was more frequent than in the female control (92.5 vs 71.8%, p=0.014), while COL1A1 rs1107946 rare A allele was more prevalent in the male athletes group than in the male control (23 vs 14.2%, p=0.01). The proportion of COL3A1 risk genotype AA, observed in controls was larger than in all athletes (8.2% vs 2.7%, p=0.04). The odds ratio of athlete harboring COL3A1 A allele compared to control was 0.2 (95%CI: 0.05-0.61, p=0.012).

### CONCLUSION:

The superior abilities of Lithuanian athletes (phenotypic data) in specific sports corresponds high-elite level. It has been found that collagen gene variants are important for anthropometric and physical characteristics, and risk of injuries; furthermore, have different effects on the physical capacity of male and female. Carrying the COL3A1 AA genotype have less chance to being a professional athlete (OR=0.2; p=0.012). However, COL1A1 rs1107946 A allele, COL1A1 rs1800012 C allele, and COL12A1 rs970547 T allele are related to the sprint/power abilities of athletes.

## EFFECT OF DICHLOROACETATE AND R-ALPHA-LIPOIC ACID ON PALMITATE-INDUCED INHIBITION OF PYRUVATE DEHYDROGENASE COMPLEX AND MITOCHONDRIAL ATP PRODUCTION IN C2C12 MYOTUBES

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### INTRODUCTION:

Increased availability of fatty acid results in the reduction of muscle mitochondrial pyruvate dehydrogenase complex (PDC) activity, which is a hallmark of metabolic inflexibility (MI) and insulin resistance (IR). Dichloroacetate (DCA) and (R)-alpha-lipoic acid (RALA) are two compounds that have been shown to improve glucose metabolism. However, whether DCA and RALA reverse the fatty acid-induced reduction of mitochondrial PDC controlled carbohydrate (CHO) oxidation and its possible mechanism is still not clear. In this study, we investigated changes in cellular metabolism and transcription factors we hypothesised may be responsible for the induction of MI in C2C12 myotubes following DCA and RALA administration in the presence and absence of palmitate treatment.

### METHODS:

We assessed the efficacy of 30 mM DCA and 200 uM lipoic acid supplementation at recovering glucose uptake, PDC activity, intermediary metabolism and mitochondrial ATP production using pyruvate + malate as a substrate in mouse C2C12 myotube differentiated cells co-treated with and without (control) 500 uM palmitate. We also investigated the association between changes in selective cellular metabolism intermediates (lactate and acetylcarnitine) and the expression of genes thought to regulate muscle fuel utilisation (PPARalpha, PPARdelta, PDK4 and FOXO1).

### RESULTS:

Compared to control, RALA, but not DCA, rescued the palmitate-induced reduction in the cellular glucose uptake. Both DCA and RALA reduced the media lactate concentration in the presence of palmitate. Palmitate reduced the C2C12 myotubes' PDC activity, which was rescued by both DCA and RALA. DCA, but not RALA, reversed the palmitate-induced reduction in the cellular acetylcarnitine content. RALA rescued the palmitate-induced reduction in the pyruvate derived mitochondrial maximal ATP production rate. Palmitate increased the myotubes PDK4 mRNA and protein levels, which was rescued by DCA only. Palmitate increased the myotubes PPARalpha and FOXO1 mRNA expression, which was reversed by DCA, but not by RALA. DCA decreased PPARdelta and FOXO1 mRNA expression. However, the administration of RALA did not affect PPARalpha, PPARdelta and FOXO1 mRNA expression in the presence of palmitate.

### CONCLUSION:

In conclusion, the present results show that palmitate decreased glucose uptake, PDC activity, and mitochondrial ATP production rate, which is a hallmark of insulin resistance. DCA improved PDC activity by decreasing PPARdelta and FOXO1 mRNA expression. However, DCA could not rescue the palmitate-induced reduction in the pyruvate derived mitochondrial maximal ATP production rate. However, RALA reversed the palmitate-induced reduction in cellular glucose uptake, PDC activity, and mitochondrial ATP production via a PDK4-independent pathway. These results suggest RALA protects against the FFA mediated inhibition of PDC activity and the glucose-derived pyruvate mitochondrial ATP production.

**COLLAGEN-RELATED GENES ASSOCIATE WITH ELITE STATUS IN RUGBY**

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**INTRODUCTION:**

Elite rugby has one of the highest reported injury incidences of any professional sport (Brooks and Kemp, 2008). Some of the most severe injuries are those affecting tendon and ligament (Brazier et al., 2019), and therefore potentially the most debilitating to a player and playing squad. Achilles tendon pathology and anterior cruciate ligament rupture are multifactorial conditions. The aetiology of these injuries are due to a number of intrinsic and extrinsic factors, with a growing body of evidence suggesting that some inter-individual variability in injury susceptibility may be due to genetic variation (September et al., 2006). Elite rugby athletes (RA) potentially have a unique ability to recover from or withstand performance limiting or career-ending soft tissue injury to achieve their elite status. Thus, it was hypothesised that RA would possess genotypes associated with reduced soft tissue injury compared to a non-athlete control population.

**METHODS:**

Participants from the RugbyGene project were elite Caucasian male RA (n = 636; mean (standard deviation) height 1.85 (0.07) m, mass 101 (12) kg, age 28 (7) yr), including 535 rugby union athletes and 104 rugby league athletes. Non-athletes (NA) were 722 Caucasian men and women (58% female; height 1.69 (0.10) m, mass 72 (14) kg, age 41 (23) yr). PCR of genomic DNA was used to determine genotypes using TaqMan probes, then groups were compared using X2 and odds ratio (OR) statistics, with alpha set at P<0.05.

**RESULTS:**

COLGALT1 rs8090 AA genotype was more frequent in RA (27%) compared to NA (23%) (X2 = 12.6, P = 0.002; OR = 1.48, 95% confidence intervals (CI) = 1.1-2.0), and NID1 rs4660148 TT genotype was more frequent in RA (10%) compared to NA (6%; X2 = 14.5, P = 0.001; OR = 1.6, 95% CI = 1.1-2.4). For MIR608 rs4919510, CC genotype was more frequent in RA (63%) compared to NA (56%; X2 = 16.4, P = 0.0003; OR = 1.7, 95% CI = 1.1-2.6). For COL3A1 rs1800255, the A-allele was more frequent in RA (26%) compared to NA (23%) due to a greater frequency of GA genotype (39%) compared to NA (33%; X2 = 9.0, P = 0.011; OR = 1.3, 95% CI = 1.0-1.6). There were no genotype differences between RA and NA for the COL1A1 rs1800012 variant.

**CONCLUSION:**

We provide evidence for elite RA possessing a possible protective genetic profile regarding tendon and ligament injury risk. Notably, more frequent COLGALT1 AA, NID1 TT, MIR608 CC and COL3A1 GA genotypes in RA suggest a lower genetic risk of injury could enhance career success in rugby. Future research should focus on establishing how gene variants affect the collagen and extracellular matrix structures, as this may underline appropriate interventions for a more individualised injury prevention and management plan.

Brooks and Kemp (2008) Clin Sports Med. 27, 51-73; Brazier et al. (2019) Sports. 7, 138; September et al. (2006) Int J Sports Med. 7, 201-215.

**COMPARISON OF ADIPOKINE SECRETION IN LONG-DISTANCE RUNNERS AND NON-TRAINING OLDER MEN**

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**INTRODUCTION:**

Endurance physical training affects the secretion of adipokines, reduces body fat and improves metabolism. It is an important factor in maintaining health especially in the elderly, reducing inflammation and insulin resistance. The aim of the study was to assess the effects of regular aerobic training on the concentration of selected adipokines in the blood of older males, compared to non-training individuals.

**METHODS:**

The study participants comprised 13 long-distance runners with a training experience of at least 5 years (RUN), and 10 non-training (NT) older males (age 58.4±3.5 and 58.3±2.5 years, p>0.05; BMI 24.1±1.9 and 27.6±3.0 kg/m2, p=0.002; FAT 21.3±4.3 and 26.7±4.0%, p=0.005; respectively). All of the subjects performed a graded test (GT) until refusal due to exhaustion. During the GT, maximal oxygen uptake relative to body mass (VO2max), as well as relative oxygen uptake at the respiratory compensation point (VO2RCP), were determined. Prior to the GT, the concentrations of leptin, resistin, adiponectin and visfatin were measured in the blood plasma.

**RESULTS:**

Relative VO2max and VO2RCP were higher in the RUN than in the NT group, and totalled 50.1±6.6 ml/kg/min and 37.6±4.5 ml/kg/min (p<0.001) as well as 40.91±6.52 ml/kg/min and 31.72±3.99 ml/kg/min (p<0.001), respectively. The concentrations of leptin, resistin, adiponectin and visfatin equalled 2.59±1.75 ng/ml and 4.36±1.08 ng/ml (p=0.014), 4.00±0.72 ng/ml and 5.26±1.43 ng/ml (p=0.012), 10.81±2.64 µg/ml and 8.92±1.97 µg/ml (p=0.049) as well as 0.33±0.21 ng/ml and 0.26±0.18 ng/ml (p=0.457), respectively in the RUN and NT groups. There was a statistically significant (p<0.05) correlation between relative VO2max and the concentration of leptin (r= -0.58), resistin (r= -0.47) and adiponectin (r= 0.51) and between relative VO2RCP, and the concentration of leptin (r= -0.53) as well as adiponectin (r= 0.49). %FAT and BMI were correlated (p<0.05) with leptin concentration (r= 0.65 and r= 0.64, respectively) and also with the concentration of adiponectin (r= -0.53 and r= -0.45, respectively).

**CONCLUSION:**

In older regularly trained men, the lower concentration of leptin and resistin and higher concentration of adiponectin in the blood were observed, compared to those non-training. Adipokine levels were associated with relative VO2max and relative VO2RCP as well as with percentage of body fat in older men.

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**AN EXAMINATION OF CHRONIC EXERCISE TRAINING ON PERIPHERAL BLOOD IN HEALTHY MALES: DEEP SEQUENCING TRANSCRIPTOMICS WITH META-ANALYSIS OF CANDIDATE SIGNATURES**

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**INTRODUCTION:**

The pleiotropic benefits of exercise are well established. However, the current gap in knowledge is compounded by an overweighing of associative studies and a paucity of experimental research conforming with Bradford-Hill criteria of causality. Thus, the present study set out to progress knowledge in a widely appreciated yet poorly understood field of exercise genetics.

#### METHODS:

We tested a physiological model of systemic exercise transcriptomics by conducting an intention-to-treat, randomised cross-over trial of healthy male participants. Following ethical approval from local IRB, eligible candidates (n=84) were screened and (n=78) enrolled to a study consisting divergent athletic phenotypes; SEDENTARY exercise-naïve (n=33), TRUE-CONTROL (n=6) and two positive control groups of AEROBIC (n=20) and RESISTANCE (n=20) trained athletes. SEDENTARY (n=28) underwent crossover exercise program consisting mixed exercise (4 weeks) before random allocation to aerobic (n=14) or resistance (n=14) training (4 weeks). Transcriptome analysis of peripheral blood cells were performed using Next Gen Sequencing (Illumina NovaSeq 6000 System, San Diego, CA). Physiological data were analysed by linear mixed model (SPSS 24.0) and transcriptomics by differential expression (edgeR package). Subsequently, PRISMA compliant, random effects, candidate signature meta-analysis is currently being completed using Stata (StataCorp LP, TX, USA) to characterise unique causative transcripts in each sedentary participant compared with respective athletic phenotypes at/above 50th percentile for respective performance measures. Meta-analytical signature heterogeneity are identified using Cochran's Q and I2 statistic.

#### RESULTS:

Study compliance was n=75/78, where TRUE-CONTROL (n=1) and SEDENTARY (n=3) participants failed to complete the trial. Thus, (n=75) participants were included in the phenotype characterization. Physiological characteristics at enrolment were consistent with athletic phenotypes [AEROBIC ( $p<0.01$ ) v STRENGTH v SEDENTARY]; [STRENGTH ( $p<0.01$ ) v AEROBIC v SEDENTARY]. The exercise intervention induced changes consistent with phenotypic adaptation. SEDENTARY (n=28) increased absolute VO<sub>2</sub>max ( $\Delta\bar{x} = +239.9$  ml.min<sup>-1</sup>,  $p<0.01$ ) and 3 x lifts (1RM) ( $\Delta\bar{x} = +30.3$ kg  $p<0.01$ ), from mixed exercise. Subsequently, endurance training improved absolute VO<sub>2</sub>max in SEDENTARY (n=14,  $\Delta\bar{x} = +347.4$   $p<0.01$ ) v control (resistance training) and resistance training improved 3 x lifts (1RM) in SEDENTARY (n=14,  $\Delta\bar{x} = +23.25$   $p<0.01$ ) v control (endurance training). These physiological changes were consistent with a phenotypic adaptation to each exercise type. Assembly and mapping of sequencing data identified 29,805 transcripts. 126 and 3 transcripts were differentially expressed between AEROBIC and STRENGTH v SEDENTARY, respectively ( $\log_{2}FC>1.5$ ,  $FDR<0.01$ ).

#### CONCLUSION:

These data will generate new knowledge on whether/not systemic transcriptomics can identify individual response to chronic exercise training.

### NEW METHOD FOR DETECTION OF STEROIDS ABUSE IN ATHLETES WITH UGT2B17 DELETION, BASED ON ANDROGENIC ACTIVITY MEASUREMENT BY AR CALUX® BIOASSAY

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#### INTRODUCTION:

According to the World Anti-Doping Agency (WADA), anabolic androgenic steroids (AAS) are the most commonly used performance enhancing drugs (PED) in sports. The consumption of this type of substances, due in part to their androgenic activity, is not safe and can lead to serious health damages.

All AAS produced by the pharmaceutical industry are derivatives from testosterone. On the testosterone structure, some changes are introduced to decrease the androgenic activity; others to make them more active when they are taken orally, or just with the goal of making it more difficult to detect its misuse. In the Anti-Doping field the detection of AAS is carried out with methodologies based on gas chromatography-mass spectrometry that are applied to extracts prepared from the athlete's urine. These types of methods are sensitive and accurate, allowing large detection windows. However, the detection of unknown compounds is not possible, because tGCMS technology only is able to detect compounds for which the system was previously calibrated with existing reference compounds.

The urinary excretion of the AAS metabolites mostly occurs as conjugates with  $\alpha$ -glucuronic acid. This phase II metabolic modification is controlled by an enzyme that can be affected in its performance by a deletion of the UGT2B17 gene. According to published data the prevalence of this deletion among Asiatic is 67% and Caucasians 9%.

#### METHODS:

The potential of BDS's AR CALUX® human cell-based biodetection technology as an indirect method to detect the administration of AAS was studied. Twelve testosterone and placebo single dose administered male volunteers were submitted to this triple-blind randomized placebo-controlled crossover trial. Among the volunteers the UGT2B17 deletion was evenly distributed among heterozygous (ins/del), wild-type homozygous (ins/ins) and mutated homozygous (del/del).

#### RESULTS:

According to our preliminary results, a significant statistical difference in terms of AAS-induced bioluminescence was observed before and after the testosterone administration for the three types of individuals. A statistically significant change in AAS-induced bioluminescence was observed ( $p<0.001$ ) in the mean of 10 determinations on consecutive days after the administration of testosterone compared to the average of the 10 determinations after the administration of placebo. The means ratio between the two treatments, depending on the type of polymorphism, was: group ins/ins 3.31 (CI: 95%: 2.07-5.29), group ins/del 4.15 (CI 95 %: 3.05-5.67) and group del/del 2.89 (CI95%: 2.42-3.46).

#### CONCLUSION:

The results of this study indicate the possibility of designing a method/approach that will permit the detection of any AAS (known or unknown) with androgenic activity independent of the type of UGT2B17 deletion.

## CP-PN10 Physiology

### THE EFFECT OF A HYPERTROPHY-ORIENTED RESISTANCE TRAINING SESSION ON ACUTE METABOLIC AND INFLAMMATORY AND IMMUNE MARKERS

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#### INTRODUCTION:

Exercise-induced hypertrophy is promoted by complex anabolic and catabolic intracellular signaling pathways, which are purported to be influenced by an exercise-induced accumulation of metabolites (1). Several factors have been hypothesized to be responsible for the anabolic effects of metabolic stress including an elevated systemic hormonal production, cell swelling and alterations in local myokines, among others (2). Some researchers have suggested that acute hormonal elevations during resistance training (RT) have a positive effect on post-exercise muscle protein synthesis (3), although this theory remains questionable (4). An emerging body of evidence indicates that local factors involved in immunological response can significantly contribute to hypertrophic adaptations by regulating anabolic and/or catabolic myokines (5). Furthermore, lactate acts as an osmolyte and thus can influence cell swelling in myocytes after a metabolically taxing exercise bout (6). In addition, microRNAs are being recently studied as potential regulators of muscle protein expression that mediate gains in strength and muscle mass (7). This study aimed to analyze the effect of a standard hypertrophy-oriented RT session on acute metabolic stress, immunological and miR-378 responses and the relationship between them.

#### METHODS:

Thirteen-trained males completed a hypertrophic RT session (3 sets x 10 RM, 2 min interset rest intervals). Venous blood samples were taken before and throughout the initial 30 min post-exercise period for determination of lactate [Lac], hormones (testosterone [T], growth hormone [GH] and cortisol [C]), cytokines (IFN $\gamma$ , IL1 $\beta$ , IL6, IL10, TNF $\alpha$ ), immunoglobulin G [IgG] and miRNA (miR-378).

#### RESULTS:

Compared to pre-exercise, RT increased serum levels of GH, and Lac ( $p < 0.001$ ), IgG ( $p < 0.05$ ), and displayed no changes in T, C, miR-378 and cytokines ( $p > 0.05$ ). An association was observed between miR-378 and C and GH ( $r = 0.606$  and  $r = 0.654$ ;  $p < 0.05$  respectively) in response to RT.

#### CONCLUSION:

Contrary to findings observed in pathological and sedentary subjects (7,8) the results did not display significant changes in miR-378 response in trained individuals. Our findings corroborate a RT effect on metabolic and GH response, while they did not appear to early affect the inflammation activation pathway, IgG, or miR-378. However, the moderate association between miR-378 and the acute hormonal response could indicate that it may play a role in the anabolic signaling pathway; further study on the topic is warranted.

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### ASSOCIATIONS OF FITNESS AND PHYSICAL ACTIVITY ON BRAIN-DERIVED NEUROTROPHIC FACTOR IN OLDER ADULTS: A SYSTEMATIC REVIEW

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#### INTRODUCTION:

Aging is a natural, gradual and inevitable process. During this process, physical exercise represents a key tool as complement to avoid the loss of functional and physical abilities, delaying appearance of neurodegenerative processes through the release of neurotransmitters, neurogenesis, and increased cerebral blood flow. Likewise, it is shown that exercise helps to increase brain-derived neurotrophic factor (BDNF), which is associated with cognitive improvement in older adults. BDNF is essential for neuronal growth and survival, participates in neuronal plasticity, making it very important for learning and memory processes. Therefore, the aim of this study was to systematically review the observational evidence regarding the associations of fitness and physical activity with BDNF levels in older adults.

#### METHODS:

A systematic search on PubMed, Web of Science, and Scopus databases was performed from database inception to February 2020, by two independent researchers. It was registered in PROSPERO with number CRD42019121647. For the search strategy, we used fitness, physical activity, BDNF, and older adult terms. The inclusion criteria were: studies with older adults (at least 65 years old), healthy people or people with cognitive impairment, and cross-sectional or longitudinal studies that analyze the relation of fitness and/or physical activity with BDNF data.

#### RESULTS:

Out of 5566 studies, a total of 3 cross-sectional studies met all the eligibility criteria, and were included in the review. The results showed a positive association of cardiorespiratory fitness and moderate and vigorous physical activity with BDNF levels. No significant relationship was found between muscular strength and frequency of walking per week with the BDNF levels. No longitudinal studies were identified.

#### CONCLUSION:

Findings from this systematic review suggest that cardiorespiratory fitness (but not muscular strength), and moderate and vigorous physical activity were associated with higher BDNF levels in older adults. Yet, due to the low number of studies found, additional studies examining physical fitness, physical activity and BDNF in older adults are needed to confirm these associations.

**PREVALENCE OF RED-S SYMPTOMS IN HIGH LEVEL KENYAN MALE AND FEMALE DISTANCE RUNNERS AND CORRESPONDING CONTROL GROUPS**

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**INTRODUCTION:**

Kenyan male and female runners have dominated international running events for decades, however the information about their endocrine and bone health to date is lacking. High training volumes and low energy intake concurrently can lead to the development of Relative Energy Deficient in Sports (RED-S) which greatly impacts on athlete's health. Previous reports on RED-S in African athletes are limited and lack comparison with the proper control group. **PURPOSE**

To examine and compare the prevalence of RED-S components/risk factors – energy intake, bone mineral density (BMD) and hormonal markers in Kenyan male and female distance runners and corresponding control groups.

**METHODS:**

Participants were 26 female (28.7±6.3 yr; 51.8±5.0 kg; 1.63±0.07 m; 19.5±2.0 kg·m<sup>-2</sup>; IAAF performance score: 1029±132 pt) and 30 male (28.1±3.8 yr; 57.7±6.1 kg; 1.73±0.05 m; 19.6±1.8 kg·m<sup>-2</sup>; IAAF performance score: 1087±66 pt) high level Kenyan distance runners. Control group consisted of 29 female (25.0±5.7 yr; 63.4±9.1 kg; 1.65±0.06 m; 23.3±3.2 kg·m<sup>-2</sup>) and 29 male (24.1±3.8 yr; 62.5±10.1 kg; 1.7±0.08 m; 21.8±5 kg·m<sup>-2</sup>) university students. Blood samples were obtained from all participants after an overnight fast. Hormonal measurements were performed on plasma specimens and consisted of luteinizing hormone, follicle-stimulating hormone, prolactin, estradiol, free thyroxine, thyroid-stimulating hormone, testosterone, triiodothyronine, insulin, and cortisol. The participant's bone mineral density (BMD) were measured at the lumbar spine (LS-BMD), right femur (RF-BMD) and total body (TB-BMD) using a dual-energy X-ray absorptiometry. Dietary intake was estimated based on each participant's self-reported food diary of seven days.

**RESULTS:**

The hormonal values we observed were variable, but within the normal expected range for healthy men and women within each of the respective measures. However, there was high prevalence of low BMD (Z-score < -1) in high level male and female Kenyan distance runners and somewhat unexpectedly for control groups too; but, no statistical differences in bone health indices between female-male athletes and corresponding control groups. Energy intake was estimated as follows: male athletes 1255.7±542.7 kcal/d, female athletes 1157.2±460.1 kcal/d, and male controls 1148.6±442.1 kcal/d, female controls 1069.9±362.2 kcal/d.

**CONCLUSION:**

We had speculated that in the presence of low energy intake, and BMD disturbances which were both found there would be anomalies in hormonal levels as well (based upon prior RED-S literature, specifically in women). Why none were seen is unclear and warrants further investigation.

**EXERCISE, DIETARY PROTEIN, AND THE COMBINED EFFECT ON IGF-1**

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**INTRODUCTION:**

Insulin-like growth factor-1 (IGF-1) is an anabolic hormone that stimulates cell growth and cell division. While beneficial for growth/repair, and regulating muscle hypertrophy, high IGF-1 concentration [IGF-1] is associated with increased risk of some cancers and mortality. Factors thought to mediate [IGF-1] include dietary protein and exercise. The purpose of this study was to analyse acute effects of dietary protein and/or exercise on plasma free [IGF-1] and the time-course of changes, in order to inform individuals who may benefit from increased [IGF-1] (muscle growth/repair) or reduced [IGF-1] (risk/diagnosis of cancer).

**METHODS:**

Twenty-four participants (11 females/13 males, 24.9 ± 4.6 y) completed the three-way crossover study consisting of: (1) a high protein (45 g; 1707 kJ) meal; (2) exercise (20 min including four 30 s sprints); and (3) exercise followed by a high protein meal. Blood samples were collected fasted at rest, immediately after rest (or 5 min after exercise), and at regular intervals throughout the following 5 h. An additional fasted blood sample was taken the morning following each condition (24 h after baseline). A linear mixed-effects regression was run to investigate the change in [IGF-1] over time for all three conditions with tests of simple main effects to determine which time points were significantly different from baseline in each condition.

**RESULTS:**

[IGF-1] was higher at 30 min (immediately after exercise) in the exercise condition (p= 0.04). In the protein condition the 24 h [IGF-1] was 17.5% higher (p= 0.02) than baseline. [IGF-1] did not change over time in response to exercise with protein. Area under the [IGF-1] curve was calculated by trapezoidal reconstruction for the time period between baseline and 300 min and was not significantly different between conditions.

**CONCLUSION:**

This research has implications for those seeking to increase or decrease [IGF-1], with repeated protein meals likely being necessary to increase basal levels of [IGF-1] in non-exercising individuals, and reduced protein intake with increased exercise to keep [IGF-1] low for individuals seeking protection against potential harmful effects of long term increases in [IGF-1].

**REPPEATED BOUT EFFECT ON CREATINE KINASE ISOFORMS IN SERUM AS A RESULT OF A 4-WEEK ISO-INERTIAL SQUAT TRAINING PROGRAM**

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**INTRODUCTION:**

This study aimed to quantify and characterize the acute increases in Creatine Kinase (CK) isoforms in serum and the protective effect against subsequent damage conferred by a structured iso-inertial resistance training program.

**METHODS:**

Eleven young volunteers ( $23.8 \pm 3.8$  years) participated in the study. Repeated measures (pre-exercise, and after 24, 48, 72, and 144 hours) were taken to determine the effects of a “maximum-effort” iso-inertial half-squat training session (10 sets of 10 repetitions) on serum biomarkers of muscle damage CK, sarcomeric mitochondrial CK (sMtCK) and CK MB isoform (CK-MB). The entire protocol was performed (A) one week before starting a 4-week iso-inertial training program and (B) one week after the completion of the program, to determine the protective effects of the training intervention.

**RESULTS:**

After A, CK, mainly located in the cytoplasm, showed consistent increases during the follow up, with peak increases from baseline of  $666.34 \pm 1331.69\%$  Post48hr. Mitochondrial marker sMtCK showed a very similar timeline to that of CK, but with a lower percentual increase, peaking at Post72hr ( $400.61 \pm 845.47\%$ ). Sarcomeric-located CK-MB showed an early peak increase at Post24hr ( $323.46 \pm 259.79\%$ ). Despite a greater external load performed on B (+38.9%, +21.0% and +65.3% production of concentric force, velocity and power), all markers suffered a significant ( $P > 0.05$ ) attenuation (-63.2% for CK, -71.1% for sMtCK and -72.2% for CK-MB) and only CK and sMtCK showed significant changes during the follow up. Additionally, peak increases in these markers were lower and appeared earlier than those seen after A (CK peaked  $279.61 \pm 250.18\%$  at Post24hr and sMtCK peaked  $233.08 \pm 148.61\%$  at Post24hr). Baseline levels of all markers were statistically recovered at Post72hr.

**CONCLUSION:**

The decreased activity of CK, and decreased concentration of sMtCK and CK-MB in serum after the training period as a result of acute exercise, suggest adaptive processes at multiple levels. A structured iso-inertial resistance training program generates adaptations that will confer skeletal muscle a better response to stress, tolerating much higher workloads with lower damage.

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**THE PHYSIOLOGICAL INFLUENCE OF HILLS RUNNING**

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**INTRODUCTION:**

The presence of hills during road races and marathons affects runners’ pacing strategies and performance. Minetti et al (2001) indicates that energy cost increases during uphill running and decreases during downhill running. These differences were thought to be caused by muscle activation, ground reaction force, and altered kinematics. However, this study only examined acute influence of hilly running. Previous studies have focused only on hilly terrain, and few studies have examined a combination of hilly and flat terrain. This knowledge may contribute to an understanding of the physical fitness index to be acquired by training. The purpose of this study is to investigate the influence of hills on running.

**METHODS:**

Six male runners participated in this study (mean  $\pm$  SD: age,  $23.6 \pm 1.8$  years; height,  $173.7 \pm 5.6$  cm; body mass,  $62.2 \pm 6.3$  kg;  $V_{O2max}$ ,  $63.0 \pm 5.1$  ml/kg/min). Runners ran two different conditions on a treadmill. Under hilly conditions, runners repeated level (0%; 5 min) - uphill (5%; 5 min) -level (5 min) -downhill (-5%; 5 min) running sessions three times, with an additional 5-min level running session at the end. Under level conditions, runners ran for 65 min on a level surface as a control. Under both conditions, running velocity was fixed at 85% velocity at ventilatory threshold ( $12.7 \pm 0.9$  km/h) at level. Heart rate (HR),  $O_2$  consumption, contact time (CT), aerial time (AT), step frequency (SF), and step length (SL) were measured during running and compared between both conditions. Energy expenditure (EE), carbohydrate oxidation, and fat oxidation were estimated from the equation of Peronnet et al (1991).

**RESULTS:**

$O_2$  consumption and HR were significantly increased during uphill running and decreased during downhill running; these parameters were also decreased significantly by level running and the level condition. Otherwise CT, AT, SF, and SL did not differ among conditions. There was no significant difference in the total EE(TEE) of level and hilly condition ( $831.7 \pm 78.7$ ,  $855.7 \pm 86.2$ ), but the fat oxidation rate of EE was higher in the hilly condition than the level condition.

**CONCLUSION:**

According to Padulo et al (2012), AT, SF, and SL were changed during hilly running, but the present study suggests otherwise. In previous studies, participants ran at higher velocities or under sharper graded conditions. Due to differences in these conditions, the current study may not have been sufficient to demonstrate changes in running kinematics. TEE were not significantly different but slightly higher in the hilly conditions. Carbohydrate oxidation was significantly higher under the hilly conditions. The optimal management of glycogen of whole body is essential if an Running a marathon or longer distance is to be completed in the least possible time. It was suggested that when the course includes hilly terrain, carbohydrate oxidation increases, which may lead to stalls later in the race.

**LONG-TERM HIGH-INTENSITY INTERVAL TRAINING INCREASES SERUM NEUROTROPHIC FACTORS IN ELDERLY CHINESE ADULTS**

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**INTRODUCTION:**

Cognitive decline is one of the most significant components of age-related deterioration, not only affecting elderly people’s daily lives but also leading to dementia and other neurodegenerative diseases. Studies have shown that the age-related cognitive decline can be slowed or even reversed to some extent through physical exercise. In recent years, a new training method, high-intensity interval training (HIIT), has become popular among the general population because of its short training periods and significant positive effect. However, there are few studies on HIIT for the elderly, and there have been no studies on the efficacy and mechanism of HIIT in delaying cognitive decline in the elderly. This study was carried out to investigate the effect of 12-week HIIT regimen, compared with a moderate-intensity continuous training (MICT) regimen, on cognitive function in the elderly. The goal was to provide an effective fitness method for preventing cognitive decline in the elderly.

**METHODS:**

Twenty-nine sedentary older adults (18 male and 11 female) with a mean age of  $64.8 \pm 3.9$  years were randomly divided into a sedentary control group (CON, n=9), a high-intensity interval training group (HIIT, n=10) and a moderate-intensity continuous training group (MICT, n=10). The HIIT and MICT groups performed three training sessions per week for 12 weeks on a limb coordination training device, while the CON group did not participate in any training. Pre- and post-intervention testing involved measuring anthropometric variables, physical

fitness, maximal oxygen uptake (VO<sub>2</sub>max), and cognitive performance as well as collecting venous blood to quantify neurotransmitters and neurotrophic factors.

**RESULTS:**

Twelve weeks of exercise training improved VO<sub>2</sub>max, vital capacity, sit-and-reach distance, choice reaction time and single-legged standing time in the elderly. In addition, serum concentrations of the neurotransmitters acetylcholine, dopamine and 5-hydroxytryptamine in trended upward with training. The serum concentrations of the neurotrophic factors brain-derived neurotrophic factor, nerve growth factor, neurotrophin-3 and neurotrophin-4 increased significantly in the training groups after the exercise regimen. In addition, compared to MICT, HIIT significantly increased VO<sub>2</sub>max and serum neurotrophin-3.

**CONCLUSION:**

In conclusion, HIIT is also applicable to the elderly, and compared with the traditional MICT, HIIT has a more significant effect on the improvement of cardiopulmonary function and the increase of serum neurotrophin-3 in the elderly.

**CELL-FREE DNA AS A BIOMARKER OF EXERCISE INTENSITY**

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1: UNIVERSITY OF TSUKUBA 2: RESEARCH FELLOW OF JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE 3: TSUKUBA INTERNATIONAL UNIVERSITY

**INTRODUCTION:**

Cell-free DNAs (cfDNA) extracted by liquid biopsy have been studied as a non-invasive diagnostic biomarker for various diseases, particularly in cancer (1). Previous studies suggested that blood cfDNA level was transiently increased by various exercises in humans (2). The cfDNA levels show differential kinetics compared to the typical markers of skeletal muscle damage such as creatine kinase and are increased in response to exercise. In addition, since the cfDNA levels are induced in response to stimuli, they may be a novel biomarker for certain responses to exercise, including muscle damage, inflammation, and oxidative stress (3). However, it is unclear how the exercise modulates the blood cfDNA levels. Thus, it is necessary to investigate the effect of intensity, time, style of exercise, and sex separately on the levels of the cfDNA levels. This study aimed to investigate effect of exercise on the urinary cfDNA levels, and the effects of exercise intensity on the serum and urinary cfDNA levels.

**METHODS:**

Twenty-six healthy participants (16 males and 10 females) were subjected to three types of physical conditions. The ventilatory threshold (VT) was determined from the incremental test and the participants were subjected to sedentary, low intensity (85% VT), and high intensity (115% VT) conditions for 30 minutes. Blood and urine samples were collected immediately after the tests. We measured the levels of cfDNA, creatinine (CRE), amylase (AMY), catecholamine, adrenocorticotrophic hormone (ACTH), white blood cell (WBC), hemoglobin (Hb), platelet (PLT), lactate, blood glucose, and neutrophil elastase (NE) from serum samples, and cfDNA, CRE, and AMY from urine samples.

**RESULTS:**

Our results showed that the serum cfDNA levels increased significantly after exercise in both, males and females. In addition, the increase in serum cfDNA levels depended on exercise intensity. The most abundant cfDNA fragments isolated in response to exercise were approximately 180 bp in size. Urine cfDNA levels were also increased in response to running exercise. The serum cfDNA levels showed a significant positive correlation with lactate, blood glucose, CRE, noradrenaline, ACTH, WBC, and Hb levels; however, no correlation was observed with AMY, PLT, and NE.

**CONCLUSION:**

In summary, this study showed that running exercise increased the cfDNA levels in serum and urine. Moreover, the increase in cfDNA level depended on the exercise intensity.

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**EFFECTS OF EXERCISE TRAINING ON BRAIN FUNCTION IN BETA-AMYLOID-TREATED OBESE RATS**

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**INTRODUCTION:**

Obesity and aging are representative risk factors for metabolic diseases including dementia induction, and exercise training is considered to be an effective way to prevent these risk factors. This study analyzed the changes in brain function, blood inflammatory markers, muscle and hippocampal brain function-related myokines after exercise training and beta-amyloid treatment in high fat diet-induced obese rats.

**METHODS:**

This study was conducted after 6 weeks of high fat diet-induced obese rats, and treated with beta-amyloid and exercise training. Subjects were divided into treatment+exercise group, obesity+beta-amyloid treatment+diet control group, obesity+beta-amyloid treatment+diet control+exercise group. Variables related to cognitive function, exercise ability, inflammatory variables in blood, brain function-related cytokines of muscle and hippocampus were analyzed.

**RESULTS:**

Water Maze test results showed a significant ( $p < 0.05$ ) decrease in the beta-amyloid treatment group, but significantly ( $p < 0.05$ ) improved after exercise training. Muscle strength and endurance were the lowest ( $p < 0.05$ ) in the obesity+beta-amyloid treatment group, but the exercise training group was the highest ( $p < 0.05$ ) regardless of obesity and beta-amyloid treatment. Serum CRP and MDA levels were highest ( $p < 0.05$ ) in the beta-amyloid treatment+obesity group, and the exercise training group showed a significant decrease. Serum beta-amyloid concentration decreased significantly ( $p < 0.05$ ) after exercise training. Muscle BDNF and FNDC5 protein expression did not show any significant difference. The expression of BDNF and FNDC5 proteins in the hippocampus tended to decrease in obesity and beta-amyloid treatment groups, and recovered after exercise training. However, there was no statistical significance.

**CONCLUSION:**

Obesity and beta-amyloid treatment resulted in a significant decrease in brain function, but could be recovered by exercise training. Expression of BDNF by exercise training related to brain function improvement was confirmed in hippocampus but did not affect muscle.



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## CP-PN11 Temperature

### A TORSO BURN INJURY DOES NOT EXACERBATE THERMOREGULATORY STRAIN DURING EXERCISE-HEAT STRESS WHILE WEARING A MILITARY COMBAT UNIFORM

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#### INTRODUCTION:

The ability to dissipate heat during exercise is impaired in individuals with grafted skin over a large portion of their body. However, it is unknown whether a torso burn injury impairs thermoregulatory function in uniformed military personnel operating in a hot environment. Purpose: To evaluate whether a torso burn injury exacerbates the rise in core temperature during exercise in a hot environment while wearing a military combat uniform.

#### METHODS:

Ten healthy individuals (8 males) performed 60 min of treadmill walking at 5.3 km/h with  $3.7 \pm 0.9\%$  grade incline (altered to maintain a rate of metabolic heat generation of  $\sim 6.0 \text{ W} \cdot \text{kg}^{-1}$ ) in a  $40.0 \pm 0.1^\circ\text{C}$  and  $20.0 \pm 0.6\%$  relative humidity climate chamber. On separate, randomized occasions, participants wore a standard U.S. Army Combat Uniform and Outer Tactical Vest (Uniform) with or without a simulated burn injury imposed by placing absorbent vapor-impermeable material across the torso, 20% body surface area (BSA), to hinder evaporative heat dissipation (Uniform + Burn). A third trial was conducted without the uniform or simulated burn with subjects wearing athletic shorts and sports bra for females (Control). Rectal temperature and heart rate were monitored continuously, and metabolic heat production was calculated via indirect calorimetry. The change in outcome measures from baseline to the end of exercise were compared between trials with a two-way (group  $\times$  time) repeated-measures ANOVA.

#### RESULTS:

At the end of exercise, no differences were revealed ( $P > 0.05$ ) between the Uniform versus Uniform + Burn trials in all outcome variables: increase in rectal temperature (Uniform:  $\Delta 1.16 \pm 0.3^\circ\text{C}$ ; Uniform + Burn:  $\Delta 1.21 \pm 0.4^\circ\text{C}$ ), thermal sensation (Uniform:  $6.0 \pm 0.6$ ; Uniform + Burn:  $6.2 \pm 0.8$ ), rating of perceived exertion (Uniform:  $14.2 \pm 2.7$ ; Uniform + Burn:  $14.1 \pm 3.0$ ) and increase in heart rate (Uniform:  $\Delta 61 \pm 13$ ; Uniform + Burn:  $\Delta 56 \pm 15$  bpm). In contrast, the Control trial showed lower ( $P < 0.05$ ): increases in rectal temperature ( $\Delta 0.93 \pm 0.3^\circ\text{C}$ ), thermal sensation ( $4.8 \pm 0.7$ ), rating of perceived exertion ( $11.3 \pm 2.2$ ), and increases in heart rate ( $\Delta 44 \pm 14$  bpm) compared to both the Uniform and Uniform + Burn trials.

#### CONCLUSION:

A 20% BSA simulated burn on the torso does not exacerbate thermoregulatory strain during exercise in a hot environment while wearing a military combat uniform in healthy young adults. These findings suggest that the risk of heat-related illness in soldiers with torso burn injuries is no different than non-injured soldiers when wearing a standard military combat uniform.

### A PILOT STUDY TO DETERMINE WHETHER REPEATED POST-EXERCISE CRYOTHERAPY EXPOSURE AUGMENTS PHYSIOLOGICAL AND PERCEPTUAL RESPONSES TO COLD.

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#### INTRODUCTION:

Cold water immersion (CWI) is a popular recovery strategy employed by athletes attempting to expedite recovery following strenuous exercise. Cold exposure is known to upregulate the production of the potent vasoconstrictor endothelin-1 (ET-1) which could augment the cooling potential, and efficacy, of CWI over time. Therefore, the aim of this study was to investigate the influence of repeated post exercise CWI on circulating ET-1 and perceptions of thermal comfort and sensation.

#### METHODS:

Seven resistance trained males (age  $26 \pm 6$  years; height  $1.71 \pm 0.06$  m; mass  $74.8 \pm 8.3$  kg) completed an 8 week lower body resistance training program. Participants completed 2 training sessions per week with each session followed by a CWI protocol (10 min at  $10^\circ\text{C} \pm 0.5^\circ$ ). At the first and last training session (sessions 1 and 16 respectively) blood samples were taken to analyse circulating levels of ET-1, and measures of thermal sensation and comfort were recorded after 5 minutes of the post-exercise CWI protocol. Participants were asked to rate their thermal sensation on a nine point standard scale. Participants were asked 'How are you feeling now?' and responded by pointing to the scale where 4 = very hot, 3 = hot, 2 = warm, 1 = slightly warm, 0 = neutral, -1 = slightly cool, -2 = cool, -3 = cold and -4 = very cold. Thermal comfort was also assessed using a five-point scale ('Do you find this,' 0 = comfortable, 1 = slightly uncomfortable, 2 = uncomfortable, 3 = very uncomfortable, 4 = extremely uncomfortable). Data were analysed using T-tests to assess changes in thermal sensation, thermal comfort and ET-1 from session 1 to 16.

#### RESULTS:

The results demonstrated that thermal sensation was significantly increased ( $t(6) = -2.75$ ,  $p = 0.03$ ) and thermal comfort was significantly improved ( $t(6) = 4.07$ ,  $p = 0.006$ ) from session 1 to session 16. Despite an increase in mean scores from session 1 to 16, there was no statistically significant alteration in ET-1 ( $t(5) = -0.69$ ,  $p = 0.52$ ).

#### CONCLUSION:

The findings from this study demonstrate that participants felt 'warmer' and experienced less discomfort during CWI from session 1 to 16. This indicates that individuals regularly using CWI as a recovery intervention are likely to experience perceptual habituation as a result of repeated exposure. Further investigation is warranted to understand the potential influence of CWI on ET-1 and the impact this may have on peripheral blood flow and skeletal muscle cooling.

**RISK FACTORS, PREVENTIVE MEASURES AND EMERGENCY TREATMENT FOR EXERTIONAL HEAT ILLNESS (EHI) IN RECREATIONAL AND ELITE SPORTS**

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**INTRODUCTION:**

A compensated body heat balance is prerequisite for health and physical performance. To dissipate the metabolic heat of strenuous muscular work, appropriate conditions (clothing insulation, climate) are essential.

However, recreational and elite athletes are increasingly faced with hot climatic conditions (global warming; intl. competitions at hot venues: Tokyo, Qatar, Melbourne etc.), resulting in a growing risk for exertional heat illness (EHI). This abstract focusses on risk factors, preventive measures and emergency treatment of severe EHI.

**METHODS:**

A selective literature research was conducted in PubMed and complemented with a search for current guidelines, guidance sets, and recommendations.

**RESULTS:**

Besides metabolic heat production, clothing insulation, and climate, additional factors contribute to the risk of uncompensable heat stress. Abrupt heat waves, or rapid change of climate zones (air travel) do not allow for adequate heat acclimatisation. Present characteristics of recreational athletes (e.g. overweight, cardiovascular risk factors) as well as acute infections, dehydration i.a. reduce heat tolerance in all athletes [1].

Preventive measures need to be merged into a comprehensive heat stress management [2] including: medical screening [3], organisational measures to reduce heat exposure (temporal & geographical relocation of sports events), recommendations for fluid and electrolyte balance, and education about adequate acclimatisation and physical fitness [4].

Furthermore, because life-threatening exertional heat stroke (EHS) may manifest itself seemingly without warning, information for the timely diagnosis and the subsequent immediate initialisation of emergency measures must be disseminated. Successful therapy of EHS depends on effective cooling (core temperature <40°C) within the first 30 min [1, 5].

**CONCLUSION:**

Our literature research shows that physical exertion can lead to EHI even in moderate climates. Higher risks may be present for sport beginners and returnees compared to elite athletes as e.g. some 58% of recreational long-distance runners had no pre-emptive medical check-up [3]. As EHS is more likely in persons with undetected pre-existing medical conditions, more attention should be paid to preventive as well as emergency measures.

To reduce heat related hazards during sports events, a proactive estimation of the potential risk imposed by climatic conditions is strongly recommended by using a climatic index (e.g. WBGT).

Moreover, support staff (medical assistants, physicians) should be trained in the diagnosis and emergency treatment of EHI. Reliable measurements of core temperature, measures of immediate and effective cooling before and during transfer to hospital are required for a successful clinical treatment.

1 Leyk D et al.: Dtsch Arztebl Int 116, 537-44, 2019

2 NATO: RTO-TR-HFM-187, 2013

3 Leyk D et al.: Dtsch Arztebl Int 105, 609-14, 2008

4 ACSM: Exertional Heat Illness during Training and Competition. 2007

5 Epstein Y: WMM 62, 359-60, 2018

**DOSE RESPONSE EFFECT OF ICE SLURRY INGESTION ON ENDURANCE CAPACITY AND SUBSEQUENT RECOVERY – IS LESS, MORE?**

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**INTRODUCTION:**

Pre-exercise ingestion of 7.5–8g/kg of ice slurry has been shown to improve endurance capacity and performance. However, consumption of such large volumes of ice slurry prior to exercise may not be practical. Whether ice slurry ingestion in lower dosages could provide comparable performance benefits is uncertain. Thus, we investigated the dose response effect of ice slurry ingested at normal or low dose on endurance capacity and recovery.

**METHODS:**

Six physically active males (mean±SD: age 25±1; VO<sub>2</sub>max 50±3ml/kg/min) completed a familiarisation and four randomised, counterbalanced trials (Tdb: 29.0±0.2°C, RH: 70±4%). Each trial consisted of 4 phases – pre-exercise drinking, treadmill exercise (60% VO<sub>2</sub>max for 45 min), endurance capacity test (ECT; 70% VO<sub>2</sub>max until volitional exhaustion) and post-exercise recovery. Participants ingested either ice slurry (ICE) or ambient drink (AMB) at two different dosages. During the drinking and recovery phases, participants ingested either 8g/kg (Normal dose trials; prefix N) or 4g/kg (Low dose trials; prefix L) of drinks, provided every 5 min, in 6 equal aliquots. During the treadmill and ECT phases, participants ingested either 2g/kg (N) or 1g/kg (L) every 15 mins. Heart rate (HR), gastrointestinal temperature (T<sub>gi</sub>), mean weighted skin temperature (T<sub>sk</sub>), sweat rate, rating of perceived exertion (RPE) and thermal sensation (RTS) were assessed using two-way ANOVA or paired Student's t-test with p<0.05 as statistically significant.

**RESULTS:**

At the end of pre-exercise drinking, T<sub>gi</sub> was lower for N+ICE (36.5±0.3°C) compared with N+AMB (37.0±0.1°C; p<0.001) and L+ICE (36.9±0.2°C; p<0.01). During the treadmill phase, both N+ICE and L+ICE trials resulted in lowered T<sub>gi</sub> (p<0.001) and HR (p<0.05) profiles as compared with AMB trials. End T<sub>gi</sub> was not different between N+ICE and L+ICE (p=0.640). Sweat rate was lowered for N+ICE (1.14±0.12L/h) compared with N+AMB (1.26±0.18L/h; p<0.01), and L+ICE (1.17±0.15L/h) compared with L+AMB (1.23±0.18L/h; p<0.05). Similarly, % body mass change was reduced in N+ICE (-0.67±0.14%) compared with N+AMB (-0.80±0.18%; p<0.01), and L+ICE (-1.0±0.14%) compared with L+AMB (-1.1±0.17%; p<0.01). T<sub>sk</sub> profile (p<0.001) was lower for N+ICE compared with N+AMB. However, L+ICE resulted in a higher T<sub>sk</sub> profile (p<0.001) when compared with L+AMB. ECT run time was not different across trials (p=0.604). During the recovery phase, N+ICE and L+ICE significantly lowered T<sub>gi</sub> profiles (p<0.05) when compared with AMB trials.

**CONCLUSION:**

Normal dose ice slurry ingestion was able to reduce thermal and cardiovascular strain during exercise. However, a compensatory effect evidenced by dampened vasomotor and sudomotor responses were also observed. Low dose ice slurry ingestion was able to achieve a reduction in thermal strain without seemingly compromising the vasomotor response. Therefore, a lower dosage of ice slurry could provide sufficient cooling benefits without compromising thermoregulatory responses during exercise in hot and humid environments.

### **EFFECT OF ACUTE HEAT EXPOSURE ON DETERMINATION OF EXERCISE THRESHOLDS USING DIFFERENT EXERCISE TEST PROTOCOLS**

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#### **INTRODUCTION:**

Exercise tests is widely used in the field of sports science. The physiological outcomes of these tests are impaired during exercise in hot environmental conditions. Main goal of this research was to investigate the acute heat-effects on exercise performance parameters derived from two different exercise tests: a ramp incremental exercise test to determine the ventilatory thresholds and a step incremental exercise test to define the lactate thresholds.

#### **METHODS:**

Eleven male participants conducted four exercise tests; two ramp and two step maximal incremental exercise tests, one of each in moderate (MOD;  $18 \pm 1^\circ\text{C}$ ) and one of each in hot environmental conditions (HOT;  $36 \pm 1^\circ\text{C}$ ).

#### **RESULTS:**

Work rate at peak level during step test was lower in HOT vs. MOD conditions ( $306 \pm 31$  vs.  $288 \pm 29$  W), whereas of the thresholds only the second lactate threshold (LT2) occurred at a lower work rate ( $239 \pm 30$  vs.  $226 \pm 28$  W). Physiological responses at these thresholds (oxygen uptake and heart rate) were elevated in HOT vs. MOD conditions and also  $\text{VO}_2\text{peak}$  was higher in HOT vs. MOD conditions ( $P < 0.05$ ). The acute heat-effect appeared to be larger in the step exercise as time to exhaustion decreased more in the step vs. ramp exercise ( $- 81 \pm 46$  vs.  $- 18 \pm 35$  s).

#### **CONCLUSION:**

Protocols of exercise testing should be designed taking into account the environmental conditions in which exercise tests must be performed, and training and peak performance have to be delivered.

### **ASSESSING BODY CORE TEMPERATURE WITH A NOVEL NON-INVASIVE SENSOR**

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#### **INTRODUCTION:**

Athletes, soldiers, and workers who perform intense physical activities under extreme environmental conditions might be encountered with increased physiological stress. Consequently, the increase in body-core temperature ( $T_c$ ) might result in heat exhaustion and heat-stroke. Thus, following continuously changes in  $T_c$  is of utmost importance. Reliable and accurate monitoring noninvasively  $T_c$  in the field is not available, except for the temperature pills. Recently, the Tcore sensor (Dräger, Germany), which employs a unique dual-sensor heat flux technology, is commercially available and intended to be used under a hospital-controlled environment. A preliminary study with the Tcore prototype (Mazgaoker 2017) concluded that it can potentially be used under exercise-heat conditions. The present study was conducted, therefore, to evaluate the end product accuracy vs. rectal temperature ( $T_{re}$ ) under exercise-heat stress.

Reference: Mazgaoker S., et al. (2017). Measuring core body temperature with a non-invasive sensor. *J Thermal Biol* 66:17–20s

#### **METHODS:**

Healthy young males ( $n=14$ ) participated in the study, which consisted of 3 days of 60 minutes seating in a comfort environmental conditions followed by 90 minutes of moderate exercise of walking on a treadmill, in a climatic chamber under different controlled hot climatic conditions. Tcore sensors were placed on the forehead and the left wrist. Temperatures from both sensors were recorded continuously in parallel to  $T_{re}$  using a thermistor (YSI 401). Since the original model to calculate  $T_{re}$  from Tcore was found to be inadequate under the study's conditions, it was adjusted and new models for the forehead and the wrist were built. 150K measurements were used to build an independent MATLAB software algorithm and test its reliability according to the cross-validation algorithm. Bland-Altman analysis and Pearson's correlation coefficients were used to analyze the results.

#### **RESULTS:**

Measured  $T_{re}$  was between  $36.5\text{-}38.9^\circ\text{C}$ . Tcore values highly correlated  $T_{re}$ ;  $r= 0.86$  for the forehead measurements and  $r=0.80$  for the wrist measurements. The mean errors of the models were close to zero, and the mean absolute errors were  $0.20\pm 0.16^\circ\text{C}$  and  $0.27\pm 0.20^\circ\text{C}$  for the forehead and wrist, respectively. 95% of the measurements from the forehead model and 86% from the wrist model were within  $\pm 0.50^\circ\text{C}$  of  $T_{re}$ . RMSD (Root Mean Square Deviation) values were  $0.285^\circ\text{C}$  and  $0.399^\circ\text{C}$  for the forehead and wrist models, respectively.

#### **CONCLUSION:**

The developed models enable to use the Tcore sensor for assessing  $T_{re}$  under exercise-heat conditions with high accuracy. Being a preliminary controlled laboratory study, further outdoor studies should be conducted in order to verify that the Tcore can indeed be used by athletes and soldiers under field conditions.

### **THE EFFECTS OF SLURRY ICE AFTER HIGH-INTENSITY EXERCISE FOR CHANGES OF MUSCLE FUNCTIONS**

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#### **INTRODUCTION:**

After high-intensity exercises, muscle damage causes muscles pain, decline in range of motion, and decrease of muscle. The muscle damage is considered to be important problem in sports field. The popular way to recover muscle damage is cryotherapy like ice bags and cold bath. The use of them is easy and multipurpose, so they are generally used in sports field. We investigate the new material of cryotherapy, the slurry ice (SI). SI is gel ice made from saline. The size of the ice is about 20 micrometers to 30 micrometers, and the ice keeps  $-1$  degrees to  $-2$  degrees. From these features, we consider the ice keep cold for a long time, and it can cool muscles better than the block ice (BI). The aim current study is to investigate the effects of the SI for the change of muscle flexibility.

**METHODS:**

The 22 right limbs of 22 healthy man adults randomized to two groups : the SI group and the BI group. We measured passive joint stiffness (Nm/deg : PJS) as muscle flexibility, which was calculated as the slope of the passive knee flexion torque-angle curve. After measuring PJS (pre), participants performed right maximum knee flexion. Afterward, they were cryotherapy of the SI or the BI at the center of the posterior thigh for 20 minutes, and take a rest for 30 minutes. After 48 hours from cryotherapy, we measured PJS again (post). Statistical analysis was performed by Wilcoxon rank sum test to compare the amount of change of PJS between each group (pre-post).

**RESULTS:**

There was no difference in height, weight, BMI and age between the two groups. The pre PJS of the BI group was  $0.31\pm 0.14$  and the SI group was  $0.34\pm 0.13$ . And post PJS of the BI group was  $0.39\pm 0.14$  and the SI group was  $0.37\pm 0.21$ . The amount of change between pre PJS and post PJS were  $0.08\pm 0.06$  in the BI group and  $0.02\pm 0.13$  in the SI group. As a result of the statistic, the change of PJS in the SI group showed mild effect ( $p=0.06$ ).

**CONCLUSION:**

Current study showed that the SI tend to reduce muscle stiffness after exercises as the cryotherapy more than the BI. Previous studies mentioned that muscle damage and changes of stiffness after exercise cause delayed onset muscle soreness for hours to days. The cryotherapy has possibility to reduce the muscle damage and shorten time to recover it. These results suggest that the cryotherapy has the possibility to reduce delayed onset muscle soreness after exercise.

The SI is constructed from the smooth particles which enable to touch to large contact area. And the melting temperature of the SI is lower than that of the BI. Such the characteristics of the SI may take more effect than the BI to reduce the muscle damage and promote recovery after exercise.

The limitation of current study is that the number of participants and the examination is small. But the SI is a promising tool to control the muscle damage and the delayed onset muscle soreness after exercise which enable to promote better performance at next exercise.

**EFFECTS OF MIXED PRE-COOLING ON THERMOREGULATION AND AEROBIC ENDURANCE PERFORMANCE IN THE HEAT**

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**INTRODUCTION:**

The study aimed to investigate the effects of mixed pre-cooling on thermoregulation and endurance performance in the heat.

**METHODS:**

Ten trained male runners were randomly divided into two groups. The groups completed the 10 minutes standard warm-up. After warm-up, the control group (PC, n=5) ingested 7.5 g/kg sports drinks (25°C), and the mixed pre-cooling group (MP, n=5) ingested 7.5 g/kg sports drinks (5°C), and combined with using the cooling gloves called CoreControlTM. Each participants then performed the 5km time trials(TT) in the heat(30°C-31°C, 57% Relative humidity)

**RESULTS:**

During the period of pre-cooling, the interactions between pre-cooling and time were significant in gastrointestinal temperature (Tgi), body temperature (Tb) and physiological strain index (PSI) ( $p<0.001$ , ES=2.96;  $p<0.001$ , ES = 2.41;  $p = 0.001$ , ES = 1.6), and the Tgi and PSI were significantly different between PC and MP at the end of pre-cooling ( $p=0.003$ ,  $p=0.001$ ). Interactions between pre-cooling and time were not significant in skin temperature (Tsk), heat storage (HS), and heart rate (HR) ( $p = 0.975$ ,  $p = 0.263$ ,  $p = 0.071$ ). During the period of 5km TT, the interactions between pre-cooling and time were not significant in Tgi, Tsk, Tb, HS, PSI, HR ( $p >0.05$ ), and the main effect of pre-cooling on Tgi and PSI was significant ( $p=0.028$ , ES=1.68;  $p=0.013$ , ES=2.11). There was no significant difference in Sweat rates between MP and PC ( $p=0.63$ ). There was a significant difference in the 5km TT between MP and PC ( $p=0.035$ ).

**CONCLUSION:**

Cold drink combined with hand cooling can reduce the core temperature and physiological strain index before exercise in the heat, and can delay the increase of core temperature and physiological strain index during the 5km TT to improve the aerobic endurance performance.

**CP-PN12 Hypoxia and oxygenation****“MUSCLE OXYGENATION IN THE FOREARM AND IN THE VASTUS LATERALIS MUSCLES IN RESPONSE TO ALTITUDE HYPOXIA AND RESISTANCE EXERCISE: A COMPARISON BETWEEN NEPALESE PORTERS AND ITALIAN TREKKERS”**

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**INTRODUCTION:**

Altitude traveling represents an intriguing experimental model to reproduce physiological and pathophysiological conditions sharing hypoxemia as the denominator, as ageing [1]. Moreover, traveling to high altitude is nowadays very popular, and it appears necessary to provide medical advice in terms of altitude tolerance and acclimatization [2]. The main aim of this study was to investigate oxygen delivery and utilization in response to hypobaric hypoxia and to a submaximal strength exercise, taking into account several factors including muscle group and ethnic origin.

**METHODS:**

As part of the “Kanchenjunga Exploration & Physiology” project, 6 Italian trekkers and 6 Nepalese porters took part in a high-altitude trek in the Himalayas. The measurement was carried out at low (1450 m) and high altitude (4780 m). NIRS-derived parameters (Tot-Hb and TSI) were gathered at rest and after a 3-minutes submaximal resistive exercise, both in quadriceps and forearm muscles.

**RESULTS:**

Peripheral saturation (SpO<sub>2</sub>), starting from physiological values, decreased from low to high altitude in all the participants (percentage of oxygenated haemoglobin moved from  $98\pm 1$  to  $86\pm 4$  in the Italian group, and from  $96\pm 1\%$  to  $85\pm 3$  percent of saturation, in the Nepalese group;  $F_{1,10}=122.50$ ,  $p<0.001$ , partial  $\eta^2=.925$ ), confirming the typical response to high altitude ascents. TSI decreased with altitude, particularly in forearm muscles (from 66.9% to 57.3%), whereas this decrement was less evident in quadriceps (from 62.5% to 57.2%); Nepalese porters had greater values in thigh saturation than Italian trekkers. Tot-Hb was increased after exercise. At altitude, it seemed that this increase was particularly high in quadriceps. The response of diverse muscles to hypoxia, or to hypoxic exercise [3], deserves to be further explored basing of morpho-functional characterization of muscle groups.

**CONCLUSION:**

High altitude may represent a stressor to the oxygen system, capable of entailing beneficial effects in oxygen delivery and utilization: we argue about the long-term adaptive memory due to the frequent exposure to altitude. We further suggest a long-term adaptation of the Nepalese porters due to improved oxygenation in those muscles involved in a hypoxic exercise, possibly through increasing muscle blood flow. Individual factors, such as age, gender, altitude exposure time, and muscle structure should be taken into account in further investigations on oxygen delivery and utilization in altitude.

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**THE EFFECT OF OFFICIAL CROSSFIT® WORKOUTS ON TEMPORAL RELATIONS OF PHYSIOLOGICAL CHANGES: A PILOT STUDY ON THE ONSET AND OFFSET OF MUSCLE OXYGEN SATURATION AND HEART RATE**

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**INTRODUCTION:**

CrossFit® is a rapidly growing type of sports. However, it exists a big lack of research around this arising load stimulus applied in the form of high-intensity power training (HIPT). Muscle oxygen saturation (SmO<sub>2</sub>) is an emergent measurement that potentially provides new insights into physical strain. This study investigated the changes in SmO<sub>2</sub> at the vastus lateralis (VL SmO<sub>2</sub>) in comparison to heart rate (HR) during the onset (ON) and offset (OFF) of official CrossFit® workouts.

**METHODS:**

The sample consisted of one male participant (age 39, healthy, certified CrossFit® coach, competitive CrossFit® athlete). The three workouts performed (19.1, 19.3, and 19.5) were part of the qualification for the Reebok CrossFit® Games 2019 and selected based on the existence of at least one exercise with continuous knee-dominant movement pattern. ON and OFF were defined as 120 seconds from the start and finish of each workout, respectively. VL SmO<sub>2</sub> was measured through a Moxy monitor (Fortiori Design LLC, Hutchinson, Minnesota, USA), HR through a Premium monitor (Garmin, Olathe, Kansas, USA). WIMU PRO (Realtrack Systems S.L., Almería, Spain) was used for data capturing. The differences between VL SmO<sub>2</sub> and HR were tested regarding medians (Mann-Whitney U Test) and variances (Levene's Test) of HR's and VL SmO<sub>2</sub>'s percentage changes during ON and OFF.

**RESULTS:**

Regarding medians, there was no statistically significant difference between HR and VL SmO<sub>2</sub> in the ON of 19.1 (p=0.12) and 19.3 (p=0.11) but in the ON of 19.5 (p=0.03). In the OFF statistically significant difference between medians was found in 19.1 (p=0.003) and 19.5 (p<0.001) but not in 19.3 (p=0.06). The respective effect sizes were uniformly moderate to large for both ON and OFF of all workouts [19.1: r (ON)=0.45, r (OFF)=0.87; 19.3: r (ON)=0.47, r (OFF)=0.54; 19.5: r (ON)=0.62, r (OFF)=1.19]. Regarding variances, there was no statistically significant difference between HR and VL SmO<sub>2</sub> in the ON of any workout (19.1: p=0.08, 19.3: p=0.44, 19.5: p=0.2). In the OFF the variances were consistently significantly different in all workouts (19.1: p<0.001, 19.3: p=0.005, 19.5: p=0.02). In the OFF supercompensation of VL SmO<sub>2</sub> could be detected while HR did not recover. Variances and ranges measured were exclusively greater in VL SmO<sub>2</sub>, regarding both ON and OFF of all workouts observed.

**CONCLUSION:**

This study revealed strong trends towards significant differences between HR and VL SmO<sub>2</sub>. Since it captured more varying data, an increased sensitivity for physiological changes is given by SmO<sub>2</sub>: While VL SmO<sub>2</sub> development reflected specific characteristics of the HIPT stimulus through CrossFit® workouts, HR responded less distinctively and delayed to changing demands and loads. Giving priority to SmO<sub>2</sub> as an indicator for physical effort and current load situations, it might become highly beneficial in the context of training control. Relating to CrossFit®, SmO<sub>2</sub> could enhance the development of specific workout strategies.

**OXYGENATED HEMOGLOBIN CONCENTRATION OF PREFRONTAL CORTEX AND HEART RATE RESPONSES TO PASSIVE PEDALING EXERCISE USING A TANDEM BICYCLE ERGOMETER**

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**INTRODUCTION:**

We have developed a tandem bicycle ergometer. By using this ergometer, while one person performs an active pedaling exercise, the other person is allowed to do a passive pedaling exercise. This study aimed to clarify oxygenated hemoglobin concentration of the prefrontal cortex (PFC) and heart rate (HR) responses to passive pedaling exercise at different pedaling frequencies.

**METHODS:**

Healthy seven Japanese adult males (Age: 23 ± 2 year, Height: 173.6 ± 5.5 cm, Weight: 69.2 ± 14.4 kg, O<sub>2</sub>peak: 45.1 ± 6.7 ml/kg/min, mean ± SD) were participated in this study as a volunteer. All the study procedures were approved by the Ethics Committee of the Kawasaki University of Medical Welfare. We have no COI with regard to this study. Subjects had the pedaling exercise twice, one was a passive exercise, and the other was an active exercise. The load of pedaling exercise was set at 1.5kp and subjects performed an exercise for 18 minutes. Pedaling frequency was increased by 10 rpm every 3 minutes from 40rpm to 80 rpm. HR and oxyhemoglobin concentration in PFC were measured. HR was measured by using the electrocardiograph. The change in oxyhemoglobin concentration was measured by using a functional near-infrared spectroscopy (fNIRS, OEG-17APD, Spectratech Inc.). The difference in HR among the different cadence were tested using one-way ANOVA. The fNIRS data were analyzed using two-way ANOVA (passive-active factor, and cadence factor). When a significant difference was found, Bonferroni's post hoc test was done. Values of p<0.05 were considered as statistically significant.

**RESULTS:**

The HR in the active pedaling exercise significantly increased with the pedaling frequencies ( $p < 0.05$ ). The HR in the passive pedaling exercise significantly increased at 80 rpm compared to that before the exercise (before;  $77 \pm 1$  bpm, 80 rpm;  $86 \pm 12$  bpm) ( $p < 0.05$ ). The oxyhemoglobin concentration of the PFC decreased during the active pedaling exercise at 50 rpm, but did not significantly change at other pedaling frequencies. On the other hand, the oxyhemoglobin concentration of the PFC significantly increased during the passive pedaling exercise compared to the baseline. Furthermore, a significant main effect of the passive-active factor, indicating that the oxyhemoglobin concentration of the PFC during the passive pedaling exercise was significantly greater than that during the active pedaling ( $p < 0.01$ ).

#### CONCLUSION:

During the passive pedaling, the subjects were required to synchronize their leg movements to the pedal rotation that was made by the other subject performing an active pedaling exercise, and thus, the PFC may be more activated in order to orchestrate the movements. These results suggest that prefrontal blood flow increases in passive pedaling exercise, but not active. Acknowledgment: This study was supported by JSPS KAKENHI Grant Number 18K10950

## CP-PN13 Cardiovascular physiology

### LEFT VENTRICULAR FUNCTIONAL RESPONSE TO REDUCED PRELOAD CONDITIONS DURING GRADED LOWER BODY NEGATIVE PRESSURE UP TO PRE-SYNCOPE

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#### INTRODUCTION:

Cardiac function plays important role for physical performance and orthostatic tolerance. Previous studies have shown that left ventricular (LV) diastolic function evaluated by tissue Doppler early velocities of mitral annulus is reduced during decreased preload conditions. However, it is still unknown whether LV diastolic function would be preload dependent up to extremely reduced preload condition such as pre-syncope. Moreover, it is completely unclear how LV strain and twist could be affected by the extremely reduced preload conditions. Thus, the purpose of the present study was to clarify the LV functional response to reduced preload condition up to pre-syncope by using 3-dimensional (3D) and Doppler echocardiography.

#### METHODS:

Eight healthy sedentary male volunteers (age;  $24 \pm 4$  years, height;  $169.5 \pm 5.0$  cm, weight;  $66.2 \pm 8.5$  kg, mean  $\pm$  SD) underwent 3D and Doppler echocardiography during graded lower body negative pressure (LBNP) up to pre-syncope. LV ejection fraction, global strains, twist, and peak untwisting rate were evaluated by 3D echocardiography by using commercial software (TomTec). Measurements of septal and lateral mitral annular early diastolic velocities ( $e'$ ) were obtained via standard tissue Doppler imaging techniques from the apical four-chamber view with a 4.0mm sample volume. Mitral inflow velocities (E) were assessed using pulsed wave Doppler with a sample volume of 2.0mm positioned over the mitral valve leaflet tips.

#### RESULTS:

LV ejection fraction (Baseline:  $64 \pm 2$ , LBNP1/2max:  $55 \pm 4$ , LBNPpre-max:  $41 \pm 7$  %, mean  $\pm$  SD,  $p < 0.05$ , ANOVA), LV global longitudinal strain ( $-21.3 \pm 2.4$ ,  $-17.5 \pm 1.7$ ,  $-12.2 \pm 1.7$  %,  $p < 0.05$ ), and LV global circumferential strain ( $-32.6 \pm 2.4$ ,  $-26.4 \pm 3.1$ ,  $-18.1 \pm 5.2$  %,  $p < 0.05$ ) were decreased in response to LBNP. LV twist ( $17.2 \pm 3.7$ ,  $16.6 \pm 5.6$ ,  $23.6 \pm 8.0$  °,  $p < 0.05$ ) and LV peak untwisting rate ( $-139 \pm 46$ ,  $-151 \pm 54$ ,  $-267 \pm 91$  °/cm,  $p < 0.05$ ) were increased at the LBNPpre-max.  $e'$  ( $14 \pm 2$ ,  $11 \pm 1$ ,  $9 \pm 2$  cm/sec,  $p < 0.05$ ) was decreased in response to LBNP, while E/ $e'$  ( $5.9 \pm 0.8$ ,  $5.5 \pm 1.1$ ,  $7.9 \pm 2.6$ ,  $p = 0.05$ ) was not changed at LBNP1/2max and then increased at LBNPpre-max

#### CONCLUSION:

LV global strains were decreased in response to reduced preload conditions by LBNP, while LV twist, peak untwisting rate and E/ $e'$  were increased. The augmented LV twist and untwist may be compensatory mechanism to maintain LV diastolic volume against the extremely reduced preload conditions. Although E/ $e'$  is clinically used as LV filling pressure, our present finding indicates that E/ $e'$  paradoxically decreased at the reduced preload condition up to presyncope, suggesting the caution for clinical use of this index at the very low preload conditions.

### ACUTE EFFECTS OF COLD WATER INTAKE ON POST EXERCISE ORTHOSTATIC HYPOTENSION AND CARDIOVASCULAR HEMODYNAMICS

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#### INTRODUCTION:

Orthostatic hypotension (OH) is prone to occur after aerobic exercise, which is called post exercise OH (PEOH). Water intake is reported to be effective to prevent OH. However, it is unknown whether water intake would be effective to acutely prevent PEOH. The purpose of the present study was to evaluate acute effects of cold water intake on PEOH and cardiovascular hemodynamics.

#### METHODS:

Fourteen healthy adult volunteers (men/women: 7/7, age:  $20 \pm 8$  yrs old, height:  $165 \pm 7$  cm, weight:  $63 \pm 11$  kg) were recruited. Each subject visited the laboratory twice at least 3 days interval to undergo two protocols of with and without 500ml cold water intake using a randomized cross over design (Water vs. Non-Water). They underwent 30 minutes cycle ergometry at the 60-70%  $VO_{2Max}$  based on the Karvonen formula, and then took 500ml cold water within 5 minutes in the Water protocol or just sat for 5 minutes in the Non-Water protocol. OH and hemodynamics at rest were assessed before exercise (preEx), just after exercise (postEx), just after the cold water intake period (postIntake), and 20 minutes after the cold water intake period (20Intake) in each protocol. Heart rate (HR) and finger arterial systolic blood pressure (SBP) were continuously monitored with a three-lead ECG and volume clamp method (Finometer), respectively. OH was evaluated with a one-minute standing test as the criteria of  $SBP < 90$  mmHg during standing. Beat-to-beat HR and SBP at rest were evaluated during sitting for 5 minutes and averaged. Moreover, the spectral analysis for HR and SBP variabilities were used to evaluate cardiac autonomic activity and transfer function analysis between SBP and RR was used to evaluate arterial-cardiac baroreflex function.

#### RESULTS:

In both protocols, resting HR and the incidence of OH increased in postEx as compared with preEx ( $P < 0.05$ , paired t-test). Comparing the two protocols, HR was lower and SBP was higher in the Water than in the Non-Water at the postIntake and 20Intake (all,  $P < 0.05$ ). The incidence of OH was lower in the Water than in the Non-Water at the postIntake (OR: 0.093, 95%CI: 0.015-0.591, logistic regression), but similar at the 20Intake (OR: 0.417, 95%CI: 0.63-2.77). High frequency range of HR variability (parasympathetic activity) and high and low frequency ranges of transfer function gain (baroreflex function) were higher in the Water than in the Non-Water at the postIntake and 20Intake (all,  $P < 0.05$ ). The ratio of low to high frequency range of HR variability (relative sympathetic activity) was lower in the Water than in the Non-Water at the postIntake and 20Intake (all,  $P < 0.05$ ).

**CONCLUSION:**

Our present findings indicate that cold water intake may acutely prevent PEOH. Reduction of HR due to water intake is likely caused by increased parasympathetic and suppressed sympathetic activities. Improved blood pressure regulation with enhanced baroreflex function may be an underlying mechanism for the prevention of PEOH by water intake.

**THE STANDARDIZATION PROBLEM OF HRV METRICS IN ELITE ATHLETES**

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**INTRODUCTION:**

Heart Rate Variability (HRV) is a physiological phenomenon in changes of time intervals between consecutive heartbeats intervals. Analyzing the HRV parameters could be used for obtaining information about the psychophysiological state and health condition, which could be helpful in high-performance sport. In January 2020, there were around 25000 entries for the query "Heart rate variability" in the Pubmed. However, most of the HRV metrics calculated in articles were not consistent with each other. We hypothesized that these inconsistencies are due to the fact that the researchers use different algorithms for computation HRV parameters. We also showed that only some of the HRV metrics were dependent on used software.

**METHODS:**

The data for HRV analyses was gained during the implementation of the PWC 170 test from the 34 elite athletes - members of the Russian national team, age  $22.47 \pm 2.41$ . Interbeat intervals (IBI) were measured with the Polar H10 and exported with the Elite HRV. Each sample file with IBI was analyzed with three methods: the pyHRV 4.0 application for Python, Kubios HRV Standard V3.1 with detrending, and Kubios HRV Standard V3.1 without detrending. We calculated time-domain parameters: SDNN, RMSSD, NN50; frequency-domain: VLF, LF, HF, LF/HF; and nonlinear: SD1, SD2, DFA  $\alpha 1$ , DFA  $\alpha 2$ . The HRV metrics were quantified without artifacts correction. Used statistical tests included one-way ANOVA and Tukey HSD.

**RESULTS:**

We found that the results of quantification such HRV metrics as SDNN, VLF, SD2, DFA  $\alpha 2$  are independent of selected algorithms ( $p < 0.05$ ), while the results of calculation other HRV parameters: RMSSD ( $p = 0.99$ ), NN50 ( $p = 0.99$ ), LF ( $p = 0.96$ ), HF ( $p = 0.99$ ), LF/HF ( $p = 0.92$ ), SD1 ( $p = 0.99$ ), DFA  $\alpha 1$  ( $p = 0.38$ ), are dependent on implemented software.

**CONCLUSION:**

As shown, the results of the quantification of some HRV metrics are dependent on selected algorithms. We propose that citing employed software for computation these parameters in the "materials and methods" section in scientific papers is critically important for reproducible results.

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**FLUCTUATIONS IN CARDIAC STROKE VOLUME DURING ROWING**

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**INTRODUCTION:**

Preload to the heart is likely limited during rowing because both blood pressure and central venous pressure increase markedly when force is applied to the oar handle. Considering that only the recovery phase of the rowing stroke allows for unhindered venous return, rowing may induce large fluctuations in stroke volume (SV).

**METHODS:**

Eight nationally competitive oarsmen (mean  $\pm$  SD: age  $21 \pm 2$  years, height  $190 \pm 9$  cm, and weight  $90 \pm 10$  kg) rowed on an ergometer at a targeted heart rate of 130 and 160 beats per minute. SV was derived from arterial pressure waveform by pulse contour analysis, while ventilation and force on the handle were measured.

**RESULTS:**

Mean arterial pressure was elevated during the stroke at both work rates ( $127 \pm 11$  ( $P = 0.012$ ) and  $132 \pm 12$  mmHg ( $P = 0.004$ ), respectively). Also, SV changed markedly during the stroke with deviations being largest at the higher work rate. Thus, SV decreased by  $27 \pm 10\%$  ( $31 \pm 11$  mL) at the beginning of the stroke and increased by  $25 \pm 9\%$  ( $28 \pm 10$  mL) in the recovery ( $P = 0.050$ ), while breathing was entrained with one breath during the drive of the stroke and one prior to the next stroke.

**CONCLUSION:**

These observations indicate that during rowing cardiac output depends critically on SV during the recovery phase of the stroke.

**CP-SH01 Psychology: Mentoring/ Perfectionism / PA promotion****THE EFFECT OF SOCIOECONOMIC STATUS ON PERCEIVED QUALITY OF CARE IN HIGH SCHOOL ATHLETES**

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In the US, socioeconomic status has been shown to influence health care access and care.<sup>1,2</sup> The relationship of socioeconomic status to one's perceived quality of care has not been reported. Further understanding of whether gender, ethnicity, and highest level of formal education contribute to quality of care perceptions is unknown. The purpose of this study was to determine if differences exist in perceived quality of care. In the US, athletic trainers (AT) serve as the primary contact for healthcare to high school athletes. Perception of care based upon socioeconomic status is important as the US does not afford universal healthcare coverage to citizens. In most cases, care is based upon one's financial status.

Surveys were emailed to 168 ATs' in South Florida high schools. Surveys were forwarded to athletes with 67 completed. The Medical Interview Satisfaction Survey-Athletic Training (MISS-AT) was used as a tool. This survey has previously been used to assess athletes' perceptions of satisfaction regarding care in collegiate athletics.<sup>3</sup> Questions are specifically related to the availability and delivery of AT services and perceived quality of care.

Results of independent t-tests show significant differences in perception of quality of care for socioeconomic levels, ethnicity, and gender. Low socioeconomic status athletes reported a significantly lower perception of positivity in the AT clinic environment ( $p < 0.01$ ) than high socioeconomic status athletes. Hispanic athletes reported a significantly lower satisfaction than Caucasian athletes ( $p < 0.01$ ). Hispanic athletes reported significantly lower confidence in their AT's knowledge ( $p < 0.01$ ), level of respect given ( $p < 0.01$ ), perception of AT's interest in returning them to play in a timely manner ( $p < 0.01$ ), and confidence in decision to remove them from play ( $p < 0.01$ ). African American athletes reported significantly lower perceptions in the AT's rehabilitation method being ideal ( $p < 0.01$ ). Female athletes reported significantly lower satisfaction with AT services than male athletes ( $p < 0.01$ ).

Findings illustrate perceptions of patients may vary based upon not only their socioeconomic status, but also gender and ethnicity. Practitioners must consider specific needs of each athlete to provide optimal patient-centered care to overcome perceptual barriers. It is unknown if similar barriers exist in countries with universal healthcare.

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**'SINTRA GROWS HEALTHY': PRELIMINARY RESULTS OF A QUASI-EXPERIMENTAL STUDY TOWARDS THE PROMOTION OF MOTOR COMPETENCE IN PRIMARY SCHOOL-AGED CHILDREN**

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Introduction: Children's motor competences (MC) are associated with physical activity (PA) and health. Developing children's MC is one of the main aims of physical education (PE). Providing quality PE experiences from an early age is of particular importance since primary school children tend to present low levels of MC and PA.

Purpose: Within the wider context of the 'Sintra Grows Healthy', an intervention program for the promotion of children's healthy lifestyles at school, this study evaluates the impact of an educational intervention on the MC of 2nd and 4th grade primary school-aged students.

Methods: The intervention consisted on providing in-service general teachers a developmental program to increase their PE pedagogical strategies. Throughout the year, 10 generalist teachers (5 teaching in the 2nd grade, and 5 in 4th grade) had continuous collaborative support from one PE teacher to plan, conduct and evaluate. PE classes occurred at least once per week. The MOBAC battery was used to assess children's MC, before and after the intervention. Socio-demographics and PA related variables were self-reported by children's parents. The main analysis included students who had complete data for these variables in both moments. A total of 127 students (71 from 2nd year, 56 from 4th year) from 3 schools integrated the intervention group (Mean age 101.7±12.1 months; 52.8% boys). 122 students (55 from 6 classes of the 2nd grade, and 57 from 6 classes of 4th grade) from 3 schools were integrated in the control group (Mean age 103.9±14.2, months 58.2% boys). Analyses were run with student t-test, Mann-Whitney, Chi-Square, Wilcoxon for paired samples, and ANCOVA. Significance was set a 0.05.

Results: At baseline, students from the intervention group presented moderate levels of MC (scale ranging 1-8 points, object movement MC was 4.3±2.2 vs 4.4±2.3, self-movement MC was 4.8±1.8 vs 4.3±1.8; total MC can range from 1-6 and was 9.1±3.2 vs 8.7±3.4). Significant differences were only found at baseline for the self-movement ( $U=5661,5$   $p < 0.018$ ). From baseline towards the final of the intervention, within group analyses show that an increase was observable in the object movement MC, self-movement MC and total MC of the students in the intervention and control groups ( $p < 0.05$ ). The variation of the evolution was higher in the students from the intervention group compared to control group, with significant differences ( $p < 0.05$ ) observed for 2nd grade students only (object movement MC increased 0.9±2.1 in the intervention group vs 0.2±1.9 in the control group; self-movement MC 1.9±1.8 vs 1.0±1.9; total MC 2.9±2.7 vs 1.2±3.0).

Conclusion: An educational intervention, based on PE professional program to increase general teachers pedagogical competences for teaching PE, and collaborative support from PE teachers, can contribute to develop children's MC. These strategies might important to improve childrens active and healthy lifestyles.

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## PERFECTIONISM AND SPORTS INJURY: IDENTIFYING RISK PROFILES IN A RETROSPECTIVE AND PROSPECTIVE DESIGN

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### Introduction

Understanding perfectionism profiles associated with the risk of injuries could be necessary to identify injury-prone athletes and develop prevention program. The recently 2x2 model of perfectionism (1) presumed four within-person combination of perfectionistic strivings (PS) and perfectionistic concerns (PC) dimensions, among which Pure PC profile represented the most maladaptive one. So far, no study has explored them in relation with sports injury. Thus, this study examined perfectionism profiles and risk of injury comparing a retrospective design with a prospective one.

### Methods

Two independent samples of 185 (S1: M=21.23 y, SD=1.87; 60% males) and 96 (S2: M=22.32 y, SD=3.85; 52.1% males) undergraduate students of sport science completed the short form of Multidimensional Inventory of Perfectionism in sport (2). A designed survey of personal injury history was completed by S1 while personal injury data of S2 was recorded over 4-months. Subjects were categorized into previously and prospectively injured or uninjured one. A non-hierarchical (K-means) cluster analysis procedure was used in order to identify the four perfectionism profiles solution and a chi-square test was conducted to examine the differences between groups of perfectionism and injury risk.

### Results

Cluster analysis identified a four-cluster solution as a function of the different combinations of PS and PC dimensions in both samples. Cluster 1 comprised subjects (N=58 for S1; N=30 for S2) who had high scores in PS and low scores in PC (Pure PS). Cluster 2 contained participants (N=30; N=24) with low scores in both dimensions (Non-Perfectionism). Cluster 3 included subjects who had moderate scores in both dimensions in S1 (N=43) and moderate scores in PC and low scores in PS in S2 (N=15) (Pure PC). Cluster 4 comprised participants (N=54; N=27) characterizing by high scores both in PS and PC (Mixed Perfectionism). The latter showed the highest proportions of previously (87%) and prospectively injured (44,4%), followed by Pure PS (77,6%) in the S1 ( $\chi^2(3)=9.84$ ;  $p=.02$ ) and Pure PC in the S2 ( $\chi^2(3)=10.66$ ;  $p=.01$ ).

### Discussion

This is the first study to explore the interactions of perfectionism dimensions when considering injury risk. According to other studies (3), the four-cluster solution did indeed replicate in our two samples. However, the findings partially supported the 2x2 model assumptions, questioning the consideration of mixed perfectionism as the most maladaptive within-person combination in the perfectionism-injury relation using both designs. As such, coaches should buffer high levels of PC and PS in order to reduce sports injury among athletes.

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## BARIATRIC PATIENTS' PERCEPTIONS ABOUT THEIR BODY SHAPE FOLLOWING A POSTOPERATIVE PHYSICAL ACTIVITY INTERVENTION: A MIXED-METHOD STUDY

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**Introduction:** Physical activity (PA) entails several physical and psychosocial benefits which optimize bariatric surgery outcomes. Although bariatric patients usually increase their satisfaction with their body shape after surgery, little is known about the role of postoperative PA in this regard. From a mixed-method approach, this study examines bariatric patients' perceptions about their body shape following a post-operative PA intervention based on self-determination theory. **Method:** Thirty-two patients were assigned to experimental (EG; n = 17) or control groups (CG; n = 15). Patients from both groups completed the Body Shape Questionnaire (BSQ) to measure concerns about their body shape before surgery and just after the PA program (7-months after surgery). A re-test was also carried out 13 months after surgery. Additionally, semi-structured interviews were conducted 7 and 13 months after surgery with EG participants. **Results:** Preoperatively, EG showed significantly less concerns about their body shape than CG ( $d = -0.91$ , CI [-1.64, -0.18]). These differences were greater just after the PA program ( $d = -1.55$ , CI [-2.34, -0.76]). However, the differences disappeared 13 months after surgery ( $d = 0.03$ , CI [-0.67, 0.72]). Qualitative findings revealed that EG patients obtained several physical benefits (e.g., muscle mass gains) derived from the PA intervention that improved their body image. Nevertheless, new complexes related to skin folds appeared after surgery, which negatively impacted on their body evaluation. **Conclusion:** A postoperative PA intervention seems to enhance bariatric patients' concerns about their body shape. Future research should explore how PA could impact on bariatric patients' complexes related to skin folds.

## CORRELATIONS BETWEEN THE LEVEL OF COMPETITIVE ANXIETY AND ATHLETE-COACH RELATION IN YOUTH FEMALE GYMNASTS

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The quality of the athlete-coach relation has a significant role in the development of a young athletes. There have been a number of studies that indicate that empowering coaching style has a significant influence on emotional states as competitive anxiety of young athletes. However, the research in the field of sport psychology offers fewer studies on youth athletes in comparison to adult athletes in the subject of anxiety. For that reason, the aim of the current study is to determine the level of correlations between the state and trait competitive anxiety of youth female gymnasts and the components of athlete-coach relation and years of practice

**Design and Methods:** A sample of 31 girls, aged 9-16 years practicing gymnastics represented different Spanish clubs. Participants completed state and trait anxiety inventory and athlete-coach relation questionnaire and a sheet with general information.

**Results:** The results showed a significant positive correlation between trait competitive anxiety and somatic state anxiety (0.398) and negative significant correlation between years of practice and cognitive (-0.523) and somatic (-0.502) anxiety. Therefore it could be expected that the more experienced the athletes the better anxiety control they have. The statistical analysis also showed some tendencies to negative correlations between one of the parameters of athlete-coach relation as proximity and cognitive, somatic state anxiety and self-confidence.

**Conclusion:** Future research should consider more study participants also from different sport disciplines and gender.

## CP-SH02 Physical activity promotion: Adults II

### PHYSICAL LITERACY: CONCEPTUALISATION AND INTEGRATION IN HONG KONG KINDERGARTENS

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#### Introduction

Physical activity promotion in early childhood is warranted more than ever. The role of educators is in nurturing physical literacy (UNESCO, 2015), which has been defined as the motivation, confidence, physical competence, knowledge and understanding to value and pursue physical activity (Whitehead, 2013). There has been little investigation of how kindergartens promote physical literacy. This study explored in-depth the conceptualisation and integration of physical literacy by kindergarten educators.

#### Methods

A mixed-methods embedded design was adopted, and participants (N = 45) consisted of kindergarten teachers and principals who were recruited across Hong Kong districts. They answered pre- and post-interview questionnaires, and participated in face-to-face interviews. The questionnaires utilised a 5-point Likert scale; data were analysed using descriptive and non-parametric statistics. The interview questions were open-ended and exploratory; data were verified through member checking, and examined using thematic content analysis.

#### Results

Majority of the participants (69%,  $X^2 = 6.42$ ,  $p = 0.01$ ) reported low familiarity with the concept of physical literacy. The participants' physical literacy conceptualisation was associated with different forms of physical activity (e.g., outdoor play, sports, playground). Their understanding was mostly derived from informal online information sources. Following clarification of the concept, the participants generally acknowledged that physical literacy is a shared responsibility of parents, teachers, communities, and the government. Factors that could enable or restrict the integration of physical literacy in kindergartens include material resources, teaching tools, time, physical space, and parents' cooperation. Educators' training, government subsidy, and wider information campaigns are desired enablers of systematic integration of physical literacy in the kindergarten curriculum. Across participants the need for professional development, and to understand and integrate physical literacy was high; as was the perceived importance of physical literacy in child development.

#### Discussion

This study reveals a limited understanding of the concept of physical literacy among kindergarten educators in Hong Kong, and a constrained integration into the curriculum. The educators expressed the need for systematic remedies by way of government support and professional development. The findings offer directions for physical activity promotion through early childhood education policy in Hong Kong.

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### IN-SERVICE TEACHER TRAINING FOR INCLUSIVE PHYSICAL EDUCATION: IMPROVING EDUCATORS' SELF-EFFICACY THROUGH THE DIE PROGRAM

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#### Introduction

Physical Education (PE) for students with special needs has multiple benefits, such as physical, social and emotional but PE teachers usually don't feel capable of including those scholars in their regular classes. Thus, there is a need to go into detail about specific inclusive PE training programs for in-service teachers to improve their knowledge and skills. The Inclusive Sport at the School program (DIE; *Deporte Inclusivo en la Escuela* in Spanish) is part of a broad methodology of training in inclusive physical activity and PE whose origin dates back to 2012 (Pérez-Tejero et al., 2013). The aim of this study was to conduct a pilot study by developing an inclusive PE training program, based on the DIE program, and to analyze its effect on the self-efficacy of in-service teachers.

#### Methods

A total of 16 participants (11 men and 5 women,  $Age=39.19$ ,  $SDage=8.94$ ), who were actively working as PE teachers in Madrid (Spain), took part in a training course lasting for 5 sessions of 3 hours each. A quasi-experimental design without a control group and pre-test and post-test measures was adopted. Firstly, quantitative data was obtained using the Spanish version of the Self-Efficacy Scale for Physical Education Teacher Education Majors toward Children with Disabilities (EA-PEF-AD-2) (Reina et al., 2019). Secondly, at the end of the training program participants answered to open questions to collect qualitative assessment.

#### Results

Wilcoxon rank test results showed a significant increase in all the subscales (intellectual, physical and visual disabilities) and dimensions (task, specific adaptations, instructions to peers and safety-related) of the self-efficacy variable ( $p < .05$ ). Indeed, 8 out of the 9 dimensions revealed a significantly higher increase ( $p < .01$ ). Qualitative analysis advertised that participants were very satisfied with the development and structure of the course, the presentation of the content, and the experience of the instructors.

#### Discussion

While there is a need to effectively train PE teachers in order to improve their practice in regular classes (Hutzler & Barak, 2017), these findings suggest that professional development in inclusion for in-service PE teachers could increase their perceived capacity and security to effectively include students with disabilities in their sessions.

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### HOW TRADITIONAL NORWEGIAN OUTDOOR ACTIVITIES ARE CHANGING - A 10 YEAR FOLLOW UP

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Introduction: Traditional Norwegian outdoor activities such as family trips in nature (often called Sunday trips in Norwegian), gathering of mushrooms and wild berries and growing own plants to eat might be important for both increasing physical activity levels and for health in general. The aim of this study is to assess changes in these outdoor activities between 2008 and 2018 in Norway, and its relation to the sociodemographic factors gender, age, own and partners education as well as household income.

Method: This study was performed as a repeated cross-sectional study within 38 randomly chooses schools in two Norwegian counties, Telemark and Hedmark. In 2008, 1012 parents of 6th and 7th grade students at 27 of the schools completed a questionnaire including questions regarding outdoor activities. In 2018, 609 new parents of 6th and 7th grade pupils from 25 of the schools participated. Family trips in nature was dichotomized into  $\geq$ once a week vs. less than once a week, gathering and growing was categorized into  $\geq$ sometimes vs. never. Education was dichotomized into having higher education vs. not. Household income were dichotomized at median for each survey. Descriptive analyzed between groups were conducted using chi-square statistics. Binary logistic regression analyses were performed with the three outdoor activities as dependent variables including year only (model 1) and then also gender, age (continuous), education (own and partners) and household income, as independent variables.

Results: Participation in weekly family trips in nature increased from 22% in 2008 to 29% in 2018 ( $p=0.002$ ), the OR for year 2018 vs. year 2008 was 1.55. Adjusted for sociodemographic factors, the OR remained stable and significant. Partners education was the only significant sociodemographic factor ( $OR=1.72$ ), indicating the odds of those with a higher education to be 72% higher to engage in weekly family trips in nature. An increase in number of people growing plants to eat was observed, respectively 42 % in 2008 and 51% in 2018 ( $p\leq 0.001$ ),  $OR=1.36$ . However, it did not remain significant in model 2. Age was positively related to growing ( $OR=1.026$ ), as was own education ( $OR=1.35$ ). Gathering of wild mushrooms and plants remained stable from 2008 to 2018, 56% and 58% ( $p=0.60$ ) respectively. Females ( $OR=1.48$ ), age ( $OR=1.051$ ) an own education ( $OR=1.68$ ) was related to growing.

Conclusion: We observed a positive increase in family trips in nature over the time period from 2008 to 2018, and also for growing own plants for eating. Furthermore, elder parents seem to be more involved in the long-rooted traditional Norwegian grow- and gather culture, and a social gradient is apparent as those with higher education do participate more often in traditional outdoor activities.

### RESEARCH ON HEALTH QUOTIENT AND COPING STYLES BASED ON FRESHMENS LEISURE EXERCISE BEHAVIOR

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Research on Health Quotient and Coping Styles Based on Freshmens Leisure Exercise Behavior

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Introduction

Through the investigation and analysis of freshmens leisure sports, health quotients and coping styles, this paper explores the correlation between freshmens health quotients and coping styles during leisure exercise, to explore the mechanism of action among the three, in order to promote college freshmen to choose positive coping style in the case of high stress.

Methods

A total of 500 college freshmen were randomly selected as subjects for questionnaire survey, and the Health Index Scale compiled by Xie Huazhen was selected;For the measurement of coping style, the Chinese version of Simple Coping Style Questionnaire (SCSQ) prepared by Xie Yaning (1998) was used;The measurement of leisure sports was selected by Liang Deqing (1994) and others to revise the sports activity rating scale (PARS-3).In order to avoid common method deviations, before the questionnaire is filled out, try to understand the definitions of the nouns of the entries as much as possible. At the same time, emphasize the anonymity of the questionnaire and the authenticity of the answers. A total of 463 valid questionnaires were collected in this survey.

Results

The coping styles of college freshmen with different leisure exercise participation and health quotient were significantly different.

There is a certain correlation between leisure exercise, health quotient and coping style of college freshmen, and leisure exercise is positively correlated with health quotient and coping style. The improvement of health quotient level is conducive to promoting college freshmen to participate in leisure exercise, and the higher the health quotient is, the more positive the coping style of students facing high stress is. The relationship among leisure exercise, health quotient and coping style is influenced by each other.

Conclusion

Improving the freshmens health quotient level can promote their active participation in leisure exercise and improve their active coping style. At the same time, freshmens active participation in leisure exercise can also improve their health quotient and active coping style. The health quotient is closely related to the leisure exercise and coping style of college freshmen.To increase students participation in leisure exercise, we can consider focusing on cultivating students awareness of health quotient.

### PRIMARY HEALTH-CARE STAFF SELF-PERCEPTION FOR IMPLEMENTING PHYSICAL ACTIVITY ON PRESCRIPTION AT PRIMARY HEALTH-CARE SETTINGS.

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INTRODUCTION:

Nowadays, physical inactivity is one of the biggest concerns for morbidity and mortality issues in Public Health (1). Physical Activity on Prescription (PAP) approaches in the Health-Care sector are worldwide trending strategies to increase PA levels in physically inactive and sedentary patients (2). This study aims to assess the self-perception of PHC General Practitioners (GPs) and nurses at Madrid Primary Health-Care (PHC) centers for PAP implementation.

METHODS:

Two choice-modeling, Google-form questionnaires previously validated by a group of 10 experts ( $V$ 'Aiken coefficient  $>0.75$  for all 1-5Likert scale 30 questions) were sent by e-mail to all 3850 GPs and 3547 nurses working at PHC in the Region of Madrid in 2019. Differences be-

tween PHC answers were analyzed using Chi-squared test analysis, corrected by the Fisher test (SPSS, version 20). The protocol was approved by the Central Commission for research of the Region of Madrid and the Ethical committee of the Alcorcon Hospital.

#### RESULTS:

A total of 319 GPs (24% males) and 285 nurses (12% males) respondents trust in PA health-related benefits. Two-thirds considered PAP good for all kind of patients, independently of age and sex. Besides, only 15% of GPs knew current WHO PA guidelines against 76% of nurses. Both PHC respondents were more confident to promote PA (71% GPs-70% nurses) than to prescribe exercise (44% GPs-35% nurses,  $p=0.02$ ). The 98% of PHC staff showed total awareness to collaborate with some proposed PAP local resources. No positive willingness to collaborate was observed with wellness centers ( $p>0.05$ ), Physiotherapy centers ( $p<0.001$ ) and private gyms ( $p<0.05$ ). However, positive willingness to collaborate was observed in the PAP collaboration with Town Hall services, Sports centers, Policymakers ( $p<0.001$ ) and Schools ( $p<0.05$ ). Those who ended their university studies later than the year 2000 had more than 70% probability to collaborate with all PAP local resources (OR.1.70;  $p<0.05$ ). PHC staff aged 20-30yr. was more likely to collaborate with all PAP local resources than staff of  $\geq 31$ yr. (OR.2.55;  $p<0.05$ ). PHC respondents with more than 20yr. of PHC working experience had more probability to collaborate with all health professionals proposed in the questionnaire (physicians, nurses, psychologists, physiotherapists, nutritionists, sports medicine physicians, sports scientists and school teachers) in PA promotion (OR.1.50;  $p<0.05$ ) and exercise prescription (OR.1.44;  $p<0.05$ ).

#### CONCLUSION:

In spite of PHC staff are willing to collaborate in an interdisciplinary PAP approach, some identified issues should be previously attended in order to design an efficient PAP implementation at Madrid PHC settings.

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### EFFECTS OF AN OLDER ADULTS HEALTH PROMOTION PLAN ON THE SHORT PHYSICAL PERFORMANCE BATTERY (SPPB) COMPARED TO AN AGE-MATCHED GENERAL POPULATION

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#### INTRODUCTION:

Functional disability is more important than multimorbidity as mortality predictor (Landi et al, 2010). The SPPB is a commonly used test to assess frailty and/or functional status (Cabrero-García et al. 2012). The aim of this study was to evaluate the effects of a health promotion plan that included supervised physical activity (PA) on the SPPB and compare the results with reference values by age obtained from an older adults population study from Spain (Cabrero-García et al. 2012).

#### METHODS:

1,913 participants from the health promotion plan organized by the Bilbao Council (Spain) performed the SPPB test (S). Besides S, three variables were analyzed and compared, balance (E), gait speed (V) and lower extremity strength (F) separately by age. From the cohort of 1,913 participants (average age:  $78,04 \pm 5,74$ ), 87,6% were women and 12,4% men. 7,5% were less than 70 years old, 24,8% in the 70-75 years old range, 24,6% in the 76-79 years old range and 43,1% over 80 years old.

#### RESULTS:

Sample (n) and population (N) averages were obtained in the different age ranges (70-75=1, 76-79=2, >80=3) on E, V, F and S. The averages were as: 1= n [E:3,8 (0,4) – V:3,8 (0,5) – F:2,6 (1,1) – S:10,3 (1,5)] and N [E:3,2 (1,1) – V:3,3 (0,8) – F:2,6 (1,2) – S:9,1 (2,5)]; 2= n [E:3,8 (0,4) – V:3,8 (0,6) – F:2,5 (1,1) – S:10,0 (1,5)] and N [E:2,7 (1,2) – V:3,0 (0,9) – F:2,4 (1,2) – S:8,1 (2,7)]; 3= n [E:3,6 (0,8) – V:3,7 (0,7) – F:2,1 (1,1) – S:9,3 (1,8)] and N [E:2,2 (1,3) – V:2,6 (0,9) – F:2,2 (1,3) – S:7,0 (2,7)]. The Cohens d effect size as the standardized mean difference between n and N was calculated. The results were as follows: 1= (E: 0,80 – V:0,77 – F:0,09 – S:0,6); 2= (E: 1,38 – V:1,07 – F:0,09 – S:0,90); 3= (E:1,33 – V:1,38 – F: -0,08 – S:1,02).

#### CONCLUSION:

The SPPB test is a reliable and effective tool in its time-to-information ratio provided for measuring the functionality and stratification of older adults. A health promotion plan that includes supervised PA seems to be effective in obtaining better values in the SPPB as we get older compared to the general population, improving the functionality of people and avoiding prevalence of frailty, increasing the years lived with better life quality and delaying dependence.

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### BENEFITS OF AN INDIVIDUALIZED AND PROGRESSIVE MULTICOMPONENT PHYSICAL EXERCISE PROGRAM IN OLDER ADULTS ACCORDING TO THEIR COGNITIVE STATUS

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#### INTRODUCTION:

Multicomponent physical exercise, including strength, balance and endurance, has been demonstrated to be effective for improving physical fitness, cognitive and psycho-affective status and reducing frailty in people living in long term nursing homes (LTNH) 1,2. However, less evidence exists comparing these effects in people with different cognitive status. The major aim of the present research is to ascertain whether an individualized and progressive multicomponent program focused on functioning have the same benefits in LTNH residents with different cognitive status.

#### METHODS:

150 people living in LTNH, of between 70 and 103 years, participated in this single-group interventional study. Inclusion Criteria were:  $\geq 70$ years,  $\geq 50$  Barthel index,  $\geq 20$  MEC-35 and being able to stand up from a chair and walk 10 meters. The intervention consisted of 6 months training combining progressive multicomponent physical exercises and activities of daily living. Short Physical Performance Battery

## CP-SH04 Psychological responses

(SPPB) and MoCA tests were used to assess physical fitness and cognitive status respectively. Anxiety and depression were assessed by Goldberg Scale and Happiness by Spanish Subjective Happiness Scale. Quality of Life-Alzheimer Disease Scale was used to evaluate the quality of life (QoL) of the participants. Participants were divided in two groups depending on their cognitive status: MEC-35 higher than or equal to 30 and MEC-35 between 20 and 29. The study is registered in U.S. Clinical Trials (NCT04221724) and approved by the Committee on Ethics in Research of the University of the Basque Country (M10/2016/105)

### RESULTS:

While both groups improved the score in SPPB after the intervention ( $p < 0.05$ ), only participants with better cognitive status improved significantly the results in the MoCA test ( $p < 0.05$ ). There were no differences between groups in the changes in psycho-affective status. However, it is noticeable that the values for anxiety, happiness and QoL of the whole sample were significantly better at the end than at the beginning of the intervention ( $p < 0.05$ ).

### CONCLUSION:

The individualized and progressive multicomponent exercise program assayed in this research improved physical fitness and psycho-affective status in older adults living in LTNH. However, the benefits in cognition were only evidenced in participants with better cognitive status.

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## CP-SH04 Psychological responses

### GENERAL DECISION-MAKING PROCESSES OF OPEN SKILLS AND CLOSED SPORT ATHLETES. WHAT ARE THE DIFFERENCES?

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#### Introduction:

Sport improves low-level general and specific perceptual-cognitive processes (1,2). However, the possibility of improving the high-order percept-cognitive skills such as decision-making is under debate.

Our study aims to fill this gap testing the decision-making processes featuring open-skills sport athletes and closed-skills sport athletes in developmental age.

Given the nature of the task involved, fluid intelligence(3) was monitored as a confounding factor.

#### Methods:

##### Participants:

Thirty-five athletes (13 track and field athletes and 22 football players) high-level athletes, aged  $11.03 \pm 1.33$  y.o., were recruited.

##### Tasks:

A perceptual decision task with three levels of uncertainty (i.e., low, medium, and high) where participants had to score as many points as possible was used(4).

Performance (LR) and decision confidence were evaluated. Specifically, the performance was evaluated through an index called Learning Rate, while implicit decision confidence was evaluated through the bet on their decision. Raven-CPM(3) assessed fluid intelligence.

LR: No-difference in Learning Rate between the two groups in each level of uncertainty was found. Moreover, the factor intelligence was not significant.

Confidence: Analysis revealed differences between the groups in the three levels of uncertainties. In particular, football players had higher confidence in their decision than athletic athletes in the three levels. Moreover, the athletic athletes did not show differences across the three conditions as the football players did. No effect of the confounding factor intelligence was found.

#### Conclusion

Both groups performed the task equally. However, some differences arise from the analysis of implicit confidence in which football players seemed to be able to better evaluate the environment compared to athletic athletes.

In order to better understand this phenomenon, the number of the two groups should be increased and young non-athletes should be recruited.

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### EFFECT OF A SUSTAINED COGNITIVE ACTIVITY ON ASPECTS OF PERCEIVED AND PERFORMANCE FATIGABILITY: A PILOT STUDY

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#### INTRODUCTION:

Sustained cognitive activities (SCA) can lead to the symptom of fatigue, often termed mental fatigue, which can be defined as a psychobiological state characterized by an impaired cognitive and/or physical function as a result of interactions between performance and perceived fatigability.

Performance fatigability during SCA can be identified as the decline of an objective performance measure over time, whereas perceived fatigability refers to the subjective perceptions during fatiguing tasks that emerge, amongst others, from the psychological state of the individual. Studies investigating the effect of mental fatigue on physical performance measures used a SCA task (e.g. Stroop test) that was

compared to a control condition (e.g. watching a video). To better understand the effect of a SCA, we investigated changes in various perceptual responses (PRs) over time that are known to contribute to perceived fatigue as well as prefrontal (PFC) brain oxygenation (TSI%).

#### METHODS:

Seven healthy young adults (sample size calculation was conducted for adequate power) completed a SCA (60min digital Stroop task) and a control task (60min watching a neutral video) in a randomized, cross-over design. Throughout the sessions, PRs (feeling, physical and mental fatigue, perceived effort, difficulty, frustration, boredom, energy, sleepiness, motivation) were monitored at several times (1, 15, 30, 45, 59min). Additionally, TSI% of PFC was measured with functional near-infrared spectroscopy. Reaction time and accuracy were used as cognitive performance measure during the Stroop task.

#### RESULTS:

No significant CONDITION x TIME interactions were observed for the PRs. Main effects of TIME were found for feeling, physical and mental fatigue, perceived physical and mental effort, difficulty, frustration, boredom, energy, sleepiness, motivation ( $p \leq .049$ ;  $\eta^2 \geq .318$ ), and also for %-change of TSI% ( $p=.000$ ;  $\eta^2=.554$ ). Furthermore, CONDITION main effects for stress ( $p=.050$ ;  $\eta^2=.500$ ) and arousal ( $p=.018$ ;  $\eta^2=.632$ ) could be detected. Reaction time during the Stroop task showed a main effect of TIME ( $p=.001$ ;  $\eta^2=.547$ ). No significant change for accuracy over time could be identified.

#### CONCLUSION:

PRs, PFC oxygenation, and performance measures showed time-dependent changes during both conditions. Only perceived stress and arousal were different between the Stroop and video condition. A clear discrimination between the two conditions was not observable. Therefore, watching a video might be no recommendable control condition. Despite the non-significant results concerning the comparisons between conditions, the uniform development of the PRs and PFC oxygenation was higher during the Stroop task compared to watching a video. Significant improvements in reaction time and a simultaneous non-significant change in accuracy, together with changes in the PRs over time, indicate that performance and perceived fatigability should be considered separately to quantify mental fatigue.

### DOES INTEROCEPTIVE AWARENESS CHANGE DURING WATER IMMERSION IN SWIMMERS?

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#### Introduction

Interoception is a sense of the internal physiological body condition and contributes to physiological and psychological functions (Köteles et al, 2020). Moreover, interoception modulates the homeostatic system (e.g., heart rate changes, arousal temperature, hunger, touch, itch, and gut motility) and is associated with contextual experiences. However, it remains unclear whether interoception varies according to the environment, such as during water immersion (WI). Hence, we investigated swimmers and other athletes using interoceptive and time-perceptive tasks before, during, and after WI.

#### Methods

The study included 15 healthy swimmers and 15 athletes of other sports (baseball and basketball). All swimmers were in the same university swimming team and were experienced in competing at national or inter-college swim meets. The other athletes were university students who were not trained in swimming. All participants were male. To evaluate interoception, we measured (a) interoceptive accuracy (IAcc), (b) interoceptive sensitivity (ISen), and (c) interoceptive awareness (IAwa). The measurements were taken with the participants comfortably seated on a reclining armchair with a mounted headrest. Trials were performed before, during, and after 25 min of WI. Each trial comprised IAcc, ISen, IAwa, and time estimation task (TEAcc) measurements. Water and ambient temperatures were maintained at 35°C and 28°C, respectively. Water was poured up to the axillary level of each participant during WI. To measure IAcc in random order, cardiac perception was assessed using heartbeat tracking, which was silent counting of their own heartbeats during different periods, such as 25, 35, and 45 s (Schandry, 1981). No feedback was provided. To generate IAwa information, each participant immediately rated his confidence in their perceived accuracy of the response at the end of each task. This confidence judgment was made using paper/pencil on a continuous visual analog scale (VAS) that was 100 mm long. In Japanese, the VAS question was "Can you accurately report when your heart is beating?" using anchors of "Not at all confident" (0) to "Very confident" (100). ISen was assessed based on the responses to the two self-reported questionnaires: multidimensional assessment of interoceptive awareness and the 20-item Toronto Alexithymia Scale (TAS-20).

#### Results & Discussion

The mean heart rate tended to be lower in swimmers than the nonswimmers and was inversely correlated with interoceptive accuracy; these findings were consistent with a previous study (Ainley et al, 2012). Swimmers had higher IAcc and TEAcc than the other athletes. This indicates that swimmers could obtain greater internal knowledge about their bodies.

#### Conclusion

Long-term swimming training may enhance IAcc and TEAcc in WI.

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### DIFFERENCES IN PHYSICAL SELF-CONCEPT IN FEMALE STUDENTS IN SPORT SCIENCE AND OTHER DEGREES

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#### INTRODUCTION

Self-concept (SC) plays a crucial and central role in the development of personality, as noted in the main psychological theories; a positive SC is the basis of good personal, social and professional functioning, depending on it, largely, the personal satisfaction, and feeling good about yourself (Benavides, et al., 2018). Physical self-concept (PSC) is considered one of the most important markers of people's well-being (Menéndez & Fernández-Río, 2017).

According to Revuelta, et al. (2016), the influences between PSC and physical activity (PA) are bidirectional in nature, although the model that proposes PSC as an influencing factor was found to have a better fitness.

The aim of the research is to determine if there are significant differences in the PSC of female university students of Sport Science and other University Degrees

#### METHODS

738 female university students in the Basque Country completed the Physical Self-Concept Questionnaire (CAF) by Goñi, et al. (2006). Of the 738 students, 84 were students of Sport Science and 654 of other University Degrees with an average age of 20.2 (sd=1.68) years.

**RESULTS**

The average number of PA hours for female students in Sport Science is 7.7 and 3.8 for those in other Degrees.

The mean in the Physical Condition (PC) is 2.92 in non-Sport Science students and 3.76 in Sport Science students; 4.07 vs 4.37 in the SC and 3.54 vs 3.98 in the PSC. Therefore the effect size of the type of studies on the number of hours is large (Cohen's  $d=0.91$ ), medium ( $d=0.57$ ) on the PC, large ( $d=0.92$ ) on the SC and smaller on the PSC ( $d=-0.038$ ).

There are diverse significant correlations between the amount of PA hours and SC;  $r=0.355$  for PC,  $r=0.133$  for SC and  $r=0.277$  for PSC. These correlations differ between Sport Science students and other only in PC. In the case of Sport Science students, it is smaller in PC, but similar in SC and PSC.

**CONCLUSIONS**

There are relevant differences between Sport Science students and other students in both in sport practice hours and SC.

The correlation established between the volume (number of hours) of PA and PSC is lower in students of Sport Science than in students of other Degrees at the university.

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**RELATIONSHIPS BETWEEN VULNERABILITY AND PERSONALITY TRAITS AMONG JAPANESE UNIVERSITY ATHLETES**

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**Introduction**

Vulnerability, a susceptibility to damaging oneself, is a possible state of brittle or emotional hurt (Hayashi, 2002). Previous studies on vulnerability show that female athletes have higher vulnerability scores than male athletes and show a positive correlation exists between vulnerability and depressive symptoms (Yamaguchi et al., 2019). Based on the examination of these demographic data and the related factors, it is expected that the way of perceiving emotional hurt events will differ depending on the person's personality. However, no studies have ever examined the relationship between vulnerability and personality traits.

Therefore, this study aimed to examine the relationship between vulnerability and personality traits among Japanese university athletes and to identify underlying gender differences.

**Method**

The survey was conducted from December 2019 to January 2020 with 211 university athletes (men = 119, women = 92, mean age = 20.2 years, and SD = 0.77). The questionnaire consisted demographic data, Athletic Vulnerability Scale (Yamaguchi et al., 2019), and ten Items Personality Inventory for Japanese (Oshio, Abe, Katroni, 2012). Gender differences and the relationship between vulnerability and personality traits were analyzed using Pearson's correlation coefficient.

**Results**

As a preliminary analysis, unpaired t-tests showed that womens had higher venerability scores than mens ( $t = 4.88$ ,  $df = 209$ ,  $p < .001$ ). As for personality traits, the extroversion score was significantly higher in women and the openness score was significantly higher in mens. Results revealed a significant relationship between the vulnerability and personality traits in both mens and womens. Specifically, in mens, vulnerability was negatively correlated with openness ( $r = -.27$ ,  $p < .01$ ). In womens, vulnerability was positively correlated with neuroticism ( $r = .38$ ,  $p < .01$ ).

**Discussion**

In this study, mens had lower vulnerability because their higher in openness may make them take a positive attitude in interpersonal relationships. The reason why women have a relationship between with neuroticism and vulnerability is thought that women tend to be more sensitive to stress factors than men and women score high depressive symptoms.

**Conclusion**

This study revealed that men and women had different correlations between vulnerability and personality traits. Men with more openness may be less vulnerable, and women with more neurotic tendencies may be more vulnerable.

**EFFECT OF ORGANIZATION-BASED SELF-ESTEEM ON EMOTION REGULATION IN JAPANESE UNIVERSITY ATHLETES**

KATO, Y.1, KAWATA, Y.1,2, NAKAMURA, M.1,3, NOGURI, R.1, HASEGAWA, K.1, YAMAGUCHI, S.3, MUROFUSHI, Y.2, SHIBATA, N.1,2,3

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**Introduction**

Japanese university athletes often belong to club teams and participate in sports activities. Accordingly, it is considered important for them to regard themselves as competent entities in their organizations. Organization-based self-esteem is defined as "the degree to which an individual believes him[self] or herself to be capable, significant, and worthy as an organizational member" (Matsuda et al., 2009). For athletes to maintain good mental health, it is important that they appropriately control their emotions by demonstrating high levels of organization-based self-esteem. Two concepts are inherent in this "emotion regulation": "reappraisal" and "suppression" (Gross et al., 2003). Organization-based self-esteem may be associated with emotion regulation, which diminishes depressive symptoms. Examining the effects of in-house efforts to build self-esteem on emotion regulation may contribute to improved mental health among Japanese university athletes.

**Purpose**

The purpose of this research was to clarify the effects of organization-based self-esteem on emotion regulation among Japanese university athletes.

#### Method

Participants were 703 university student athletes in Japan (456 men, 247 women; average age: 19.91 years, SD = 1.18). Contents of the survey included: demographic data, the Emotion Regulation Questionnaire (ERQ), and the Japanese version of the Organization-Based Self Esteem Scale (OBSE-J). A binomial logistic regression analysis was performed with organization-based self-esteem as an independent variable and reappraisal and suppression of emotion regulation as dependent variables.

#### Results

Results showed that the risk of organization-based self-esteem on emotion regulation had a significant effect on reappraisal (OR (95% CI) = 1.9 [1.4–2.6],  $p < .001$ ). However, there was no effect on suppression.

#### Discussion

Athletes with high organization-based self-esteem were 1.9 times more likely to use reappraisal strategies than athletes with low self-esteem. These results indicate that promoting organization-based self-esteem may be effective in facilitating reappraisal for emotion regulation. Results suggest that creating an environment in which individuals regard themselves as competent, valuable, and important members of an organization provides athletes with the skills to appropriately change their perceptions of events that trigger their emotions.

#### Conclusion

Athletes with high levels of organization-based self-esteem were 1.9 times more likely to use reappraisal strategies than athletes with low levels of organization-based self-esteem.

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### EFFECT OF PSYCHOLOGICAL PRESSURE ON COGNITIVE FUNCTIONS OF JAPANESE UNIVERSITY SOCCER PLAYERS

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#### Introduction

Being nervous owing to the pressure of an important game or time pressure is called “choking under pressure” and is defined as a phenomenon in which performance is reduced by pressure [1]. Sports such as soccer, with frequent situational changes, require the ability to execute appropriate agility quickly and accurately under pressure. However, there has been no unified view on how psychological, physiological, and behavioral mechanisms lead to poor performance. Therefore, measuring the cognitive function of soccer players under pressure may clarify the mechanism of behavioral changes.

#### Purpose:

This study aimed to clarify the effects of psychological pressure on the cognitive functions of Japanese university soccer players.

#### Methods

A total of 15 male (Mage=20.7, age range: 20-22 years) Japanese university soccer players were assessed to determine their cognitive functions using Stroop color word test (SCWT), state-anxiety (STAI) [2], and heart rate, under the control and pressure conditions (electric stimulus condition, reward condition). First, STAI scores (intensity of anxiety) and heart rates (physiological arousal) were compared in each condition. The correct response rate and reaction time of the SCWT were compared in each condition using the Friedman test and the post-hoc test.

#### Results

Significant difference was found in the STAI score under the three conditions, and the electrical stimulation condition showed a higher value than other conditions ( $\chi^2 = 14.27$   $p < .001$ ). No significant difference was found in average heart rate ( $F(2, 28) = 0.01$ ,  $p > .05$ ), correct response rate ( $\chi^2 = 1.35$   $p > .05$ ), and reaction time in the SCWT ( $F(2, 28) = 0.14$ ,  $p > .05$ ).

#### Discussion

In the pressure condition, state anxiety was induced, but no influence was observed on the physiological index (average heart rate during the task). That is, electric stimulus and subjective anxiety could be induced in the players, but would not generate enough pressure to impact the physiological index. The response time of SCWT, which is an index of cognitive function, and the correct response rate were not influenced. One reason for this is that slight pressure did not cause any change because the task was simple. The simple cognitive function of Japanese university soccer players may not depend only on subjective pressure. However, in a soccer-related task requiring complicated information processing, a difference may occur.

#### Conclusion

The pressure conditions used in this study caused subjective anxiety but showed no physiological changes in the players. This suggests that simple cognitive function was not affected only by evoking subjective anxiety.

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### VALIDATION OF A QUESTIONNAIRE TO QUANTIFY THE MENTAL LOAD. PADDLE APPLICATION.

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#### INTRODUCTION:

Under a sports approach, the psychological load could be defined as the amount of mental effort necessary to develop a sport activity or task in a marked period of time, causing in the participant a certain level of mental fatigue (García-Calvo, González-Ponce, Ponce, Tomé-



Lourido, & Valés-Vazquez, 2019). In recent years, several options have been proposed to assess the mental load in sport (Ponce-Bordon, García-Calvo, López-Gajardo, Díaz-García, Ramírez-Bravo, & González Ponce, 2020; Rusell, Jenkins, Rynne, Halson, & Kelly, 2019). However, it is still difficult to find an instrument that allows to obtain specific results and fast enough to involve it in the weekly dynamics of the competition teams (García-Calvo et al, 2019).

One of the main problems for which a unitary instrument has not been found is the multidimensionality of the mental load (García-Calvo et al, 2019).

For its part,

the research that has been done about this sport has not yet found attractive the assessment of mental load (Sanchez-Muñoz, Muros, Cañas, Courel-Ibañez, Sánchez-Álcaraz, & Zabala, 2020)

**METHODS:**

574 responses to the questionnaire were registered during the federated team tournament of the different paddle federations in Spain.

The steps proposed by Angera (1991) were followed for the design of the questionnaire

The samples were analyzed with the SPSS 25.0 Statistical Software and descriptive statistics, bivariate correlation analysis and regression statistics (ANOVA) were analyzed

**RESULTS:**

The data show a non-existence of homosteaicity between the items that make up the questionnaire ( $< 0.8$ ). In addition, the reliability analysis, prepared through Cronbachs Alpha, presents values greater than 0.7 (.735). Validity values in all its components are also significant ( $<0.05$ ).

Regarding the relationship between mental load and paddle, the existence of ANOVA correlation between mental load and age, between mental load and decisive points, between mental load and relationship with the partner and between mental load and sex has been demonstrated ( $<0.05$ ).

**CONCLUSION:**

Regarding the first objective, validation of a questionnaire for measuring mental load, it can be concluded that the data show adequate reliability and validity to be able to consider the instrument as suitable for application to the sports context.

On the other hand, we can conclude that the application of this questionnaire to the sport of paddle in a federated team tournament has concluded that the outcome of the match is determined by all the items presented in the questionnaire.

Consequently, it can be determined that it will be necessary to continue investigating the practical and applied knowledge that psychology gives to work and the assessment of the mental load in the paddle, especially in the context of performance

## CP-SH05 Disability and clinical populations

### IMPACT OF PHYSICAL EXERCISE OF PEOPLE WITH PHYSICAL DISABILITY ON SOCIAL AVOIDANCE IN HENAN PROVINCE:THE MEDIATING ROLE OF MENTAL RESILIENCE

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**Introduction**

Disabled people are a large group with special difficulties in our country. To a certain extent, disability is likely to have a certain negative impact on individuals mental health. Among them, there is a high proportion of inferiority complexes among the people with physical disability due to physical defects, which in turn leads to self-closing that is unwilling to participate in social activities. How to effectively help the physically disabled to improve their mental health and increase their self-confidence is a problem that society should focus on and urgently need to solve.

**Methods**

The brief version of Mental Resilience Scale, Social Avoidance and Distress Scale and Physical Activity Scale were used for the measurement. Before filling in the questionnaire, make the physically disabled clearly understand the meaning of key terms in the entry through explanation. At the same time, the physically disabled with lower education level were interviewed to reduce the possibility of common method deviation, so as to obtain real and effective data. The recovery rate of this survey was 100%. Eight invalid questionnaires were removed, and 179 were valid.

**Results**

1. There was no significant difference in the scores of mental resilience among the physically disabled with different gender and marital status, but there was a significant difference in the scores of mental resilience among the physically disabled with education level and disability level ( $P < 0.05$ ). Specifically, the scores of mental resilience among the physically disabled with junior high school education and the fourth-level physically disabled were relatively good.

Different genders and different disability grades have significant differences in social avoidance scores for the physically disabled, secondary physical disability and male physical disability have higher social avoidance scores.

2. There is a significant correlation between physical exercise of the physically disabled and mental resilience and social avoidance. The higher the participation in physical exercise, the higher the level of mental resilience and the lower the social avoidance score; The physically disabled with better mental resilience have lower levels of social avoidance.

3. On the basis of controlling gender, age, education level and disability grade, physical exercise can directly reduce the level of social avoidance of physically disabled people, and it can also improve their level of social avoidance through mental resilience. Physical exercise predicts the outcome interval of social avoidance through mental resilience, which does not include 0. It indicates that mental resilience plays a partial mediating role between the two, and the mediating effect size is 17.97%.

**Conclusion**

Participation in physical exercise is closely related to the level of social avoidance of the physically disabled. The higher the participation of physical exercise, the lower the level of social avoidance of the physically disabled. Increasing the participation in physical exercise may be one of the important ways to reduce the social avoidance level of the physically disabled. At the same time, physical exercise can also indirectly improve the social avoidance of the physically disabled by affecting mental resilience.

### FACTORS RELATED TO DAILY STEP COUNTS OF PATIENTS WITH STROKE DURING HOSPITALIZATION IN A CONVALESCENT REHABILITATION WARD

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#### Background:

Considering that convalescent rehabilitation wards provide a living space for patients before returning home or reintegrating into society, resuming physical activity in rehabilitation wards is a crucial goal for stroke survivors. However, very few studies have quantitatively assessed physical activity levels of patient with stroke in these wards using a pedometer. Identifying the factors related to steps in ward life that are unaffected by therapist intervention is important. The present study aimed to clarify the physical factors related to daily step count during non-rehabilitation time among patients with stroke who could independently walk in a convalescent rehabilitation ward.

#### Methods:

Patients with stroke hospitalized in a convalescent rehabilitation ward were recruited. The inclusion criteria were independent walking within the ward and a walking speed of >20 m/min. Data on clinical characteristics (age, sex, stroke type, affected side, time since stroke onset) were collected from medical records. Daily steps were counted using an activity monitor (Fitbit Flex2, Fitbit Inc, USA). All patients wore the device above the ankle of the non-affected leg for 5 consecutive days. The number of steps excluding those while performing rehabilitation (physical, occupational, and speech therapies) from the total steps per day was considered non-rehabilitation steps. Motor function of the affected [Stroke Impairment Assessment Set (SIAS)] and unaffected (leg strength) lower limbs and comfortable walking speed (CWS) were examined. Differences in non-rehabilitation steps according to sex and stroke type were analyzed using Mann-Whitney test. Correlations between age, SIAS, leg strength, and CWS and non-rehabilitation steps were analyzed using Spearman's rank correlation coefficient. Multiple regression analysis was performed to identify the independent factors associated with non-rehabilitation steps using age, SIAS, leg strength, and CWS.

#### Results:

Overall, 61 patients (mean age: 59.6 ± 13.9 years; 23 females; 37 with cerebral infarction; 19 with left hemiplegia; 2.3 ± 1.2 months since onset) were included. There were 4,589 ± 2,393 non-rehabilitation steps per day. Step counts showed no significant difference in terms of sex and stroke type. Non-rehabilitation steps showed significant correlations with leg strength ( $r = 0.37$ ,  $P < 0.01$ ) and CWS ( $r = 0.38$ ,  $P < 0.01$ ) but no significant correlations with age and SIAS. There were no independent factors associated with non-rehabilitation steps.

#### Discussion:

Physical functions, such as motor functions of the affected and unaffected lower limbs, and walking speed were not significantly associated with non-rehabilitation steps in patients with stroke hospitalized in a convalescent rehabilitation ward. Therefore, future studies should consider the association of non-rehabilitation steps with cognitive or mental function factors (motivation and depression).

### RELATIONSHIP BETWEEN ORGANIZATION-BASED SELF-ESTEEM AND DEPRESSION SYMPTOMS AMONG JAPANESE UNIVERSITY ATHLETES

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#### Introduction

Athletes' membership to their team sometimes affects their mental health. Having a place of my own may foster mental stability and a self-affirmative feeling. Organization-based self-esteem has been defined as "the degree to which individuals believe they are capable, significant, and worthy as organizational members." Previous studies reported that organization-based self-esteem may foster good mental health among the Japanese.

For athletes, a place of their own is the team they belong to, where they build organization-based self-esteem. Thus, there is a possibility that athletes who have low organization-based self-esteem have mental health problems. However, no study to our knowledge has investigated the relationship between organization-based self-esteem and mental health in athletes.

Therefore, we aimed to clarify the relationship between organization-based self-esteem and depression in this study.

#### Methods

Participants were 703 Japanese university athletes (456 men, 247 women). Their demographic data was obtained, and the Japanese version of the organization-based self-esteem scale (OBSE-J) (Matsuda et al., 2011) and self-rated depression scale (SDS) (Fukuda et al., 1973) were administered to them.

We performed Pearson's correlation analyses with the OBSE-J and SDS scores to identify the relationship between organization-based self-esteem and depression of the athletes by sex.

#### Results & Discussion

The results showed that, in both men and women, organization-based self-esteem and depression symptoms had a significant negative correlation (men:  $r = -.397$ ,  $p < .001$ , women:  $r = -.365$ ,  $p < .001$ ). Thus, it was suggested, that both male and female athletes with high organization-based self-esteem tend to not have depressive symptoms.

This result was concordant with a previous study that reported that OBSE-J showed negative correlation to SDS scores in Japanese employees (Matsuda & Ishikawa, 2012). Thus, it can be concluded that the organization-based self-esteem of athletes may suppress their depressive symptoms.

## CP-SH06 Sport exercise psychology

### THE ROLE OF EYE FIXATION ENABLING MULTIPLE INFORMATION EXTRACTION FROM GLOBAL EYE FIELD

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#### Introduction

In many sports, we need to get various information simultaneously. For example, in basketball, a player needs to simultaneously perceive the movement of the opposing player and the ball present in the field of view and selects an appropriate action. At this time, difference in sensitivity in the eye field and the time for moving eye fixation point constrain the simultaneous perception of multiple objects. In this study, we examine how to modulate the information collection strategy depending on the difficulty of discrimination of each visual stimulus in the task of discriminating two simultaneous information.

#### Methods

A discrimination task of two Gabor stimuli was used in which the difficulty of discrimination depending on contrast. Since the Gabor stimuli disappeared 100ms after presentation, participants could not fixate their eyes to the targets sequentially. We used three intensities for contrast. Participants selected whether the directions of the two Gabor stimuli displayed on the screen were same or different by pressing the button. By showing the contrast of each Gabor stimulus as a sample at the beginning of each trial, participants could recognize the difficulty of discrimination prior to each trial. Based on the fixation position in each condition just as the target was presented, we examined the modulation of the eye tracking strategy depending on the conditions and its effectiveness.

#### Results

The results show that the fixation point was modulated depending on difficulty of discrimination. The fixation point changed flexibly according to the contrast of the Gabor stimuli. In the case of different contrast set, the fixation point shifted toward the more difficult stimulus. On the other hand, in same contrast set, it stayed at the middle of two stimuli.

#### Discussion

These results showed that the fixation point at the time of stimulus presentation changes according to the difficulty of discrimination, suggesting that the discrimination sensitivity of two objects that are not present in the fixation point is improved. We emphasize the role of eye fixation that enables multiple information extraction from the entire field of view, in addition to the role that enables to attend to the specific location in the eye field.

### **VALUES DIFFERENCES BETWEEN NON-ATHLETES AND ATHLETES AND THE ROLE OF VALUES AS PREDICTORS OF PERSONAL AND SOCIAL DEVELOPMENT IN ATHLETES**

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Sport and physical activity research supports sport as an educative tool, values transmitter and character developer (Côte, Strachan, & Fraser-Thomas, 2008). The Schwartz Theory suggests that exists a universal value structure, although individuals and groups may differ substantially in the importance they attribute to the values (Schwartz, 2015).

Some of the values are considered as individualistic in the way that they are focused on the one's self-interests. Meanwhile, the collectivistic values are oriented toward the collective interests (Trail & Chelladurai, 2002).

The objective of this study was to analyse the values differences between a group of young athletes and non-athletes. Additionally, whether individualistic and collectivistic values were possible predictors of personal and social development in the young athletes was also tested.

#### Methods

Participants were 426 female athletes and 231 female non-athletes aged between 11 and 34 ( $M_{age}=15\pm 2.88$ ).

#### Results

Multivariate analysis of variance (MANOVA) showed significant differences in both higher order and second order values between non-athletes and athletes. Additional contrast analysis revealed that in basic values of conformity ( $t=3.45;p<.01$ ), tradition ( $t=2.19;p<.05$ ), benevolence ( $t=3.27;p<.01$ ), self-direction ( $t=3.19;p<.01$ ), stimulation ( $t=5.43;p<.001$ ), hedonism ( $t=2.53;p<.05$ ) and achievement ( $t=4.61;p<.001$ ) are higher in athletes than in non-athletes. Also in the second order values, openness to change ( $t=4.74;p<.001$ ) and self-enhancement ( $t=2.41;p<.05$ ) were higher in athletes.

In the athletes' sample, multiple lineal regression showed that the individualistic value of self-direction was positively associated with personal development ( $t=2.74;p<.01$ ), whereas the collectivistic value of tradition was positively associated with social development ( $t=1.93;p<.05$ ).

#### Discussion

The study found significant differences between the value structure of young athletes and non-athletes. A conflict of values in athletes was revealed between the value that involves the search of independence and autonomy to achieve personal development and the value of respect and be engaged with traditions to achieve social development. It may be explained by the fact that all athletes were from team sports, where will be situations in which personal interests are opposed to team interests.

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### **CONFLICT PREVENTION METHODS FOR PHYSICAL EDUCATION TEACHERS**

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#### INTRODUCTION

Physical education teachers face numerous conflicts with their students and their students parents. The conflict management process is influenced by several factors, which PE teachers have to know, if they want to resolve conflicts effectively. The aim of this study was to map the conflict prevention methods, which are generally used by PE teachers during their work.

#### METHODS

In the focus group study twelve PE teachers took part from different school types. Some of them were at the beginning, some at the middle and the rest at the end of their career. The average length of teaching experience was 24,2 years. The questions focused on the classroom management, the pedagogical instructions and the educational activities, which reduce the appearance of conflicts.

**RESULTS**

Beginner PE teachers had difficulties mainly with discipline, which they try to resolve with appropriate pedagogical sensitivity, with situation based communication style, with the help of exemplary and strong-minded actions. The PE lessons start in the locker rooms, where the pupils change their clothes. Disciplined behaviour in the locker rooms can provide a good basis to achieve the goals of PE lessons. The criteria for good behaviour must be introduced by PE teachers at the beginning of the school year and they have to consistently enforce these. Parents should also be informed about the rules in connection with physical education lessons. Conflicts resulting from lack of sport clothes, being late from the lessons and wearing jewelery are common. A conflict can arise if the club match and the student olympics match are organized in the same time. Furthermore, while ball games are being taught, picking up balls can lead to conflicts if students want to get them from a narrow opening ball net. The conflict can be prevented by placing the balls side by side on the ground. Another cause of conflict can be an unclear indication of the goals and the track dimensions. Before ball games the team selection must be organized by the PE teachers carefully to prevent further conflicts. Substitution players should also have an adequate amount of playing opportunities.

**CONCLUSION**

According to the participants, the best conflict management methods is to prevent the conflicts. To be able to reach this goal PE teachers need to know the most common locations and causes of conflicts. Being aware of these they have to use situation based leadership-, communication- and conflict management styles. They have to create an atmosphere where they minimize the appearance of conflicts.

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**MOTOR PREPARATION FOR A MENTAL IMAGE OF CLIMBING HOLDS: A POSSIBLE INTERACTION OF TACTILE AND VISUAL INPUTS**

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**Introduction**

A mental image of an action affects motor performance. In free-climbing, climbers prepare climbing movements based on the visual and tactile information of the climbing holds. An appropriate motor preparation of grasping the holds is important for a climber's performance (Bläsing et al., 2014). In the present study, we investigated whether the tactile and visual information of the given hold would affect the motor preparation of the action.

**Method**

Fifteen climbers and fifteen non-climbers participated in the experiment. The task was to respond to a visual target presented on a computer display by pressing one of the two response buttons. The visual stimuli in a given trial were composed of a climbing hold which serves as a prime stimulus and a left or right arrow which serves as a target. The climbing hold was experimentally manipulated to present either one hold (Single Prime condition: SP) or two holds (Double Prime condition: DP). The orientation of the hold was either up, down, left or right (randomly presented). There was another condition examined the effect of the "touch", in which participants were asked to either touch a real climbing hold (touch condition) or no-touch (just watching the real hold, i.e., no-touch condition) just before running each trial of the experiment. The order of the touch/no-touch condition were counterbalanced in two different days. The reaction times (RTs) were measured in each participant as the time from the target onset to the button pressing. The participants were separated into three groups (high, low, and no experience) by their difference in climbing experience. The median of RTs obtained from each participant were fed into the ANOVA [Group (3) x Prime (2) x Touch (2)].

**Results**

A marginally significant interaction between the group, prime, and touch conditions was observed. In the high group, the RTs of SP in the touch condition were slower than those in the no-touch condition but such a touch-related effect was not observed in DP. In the no-touch condition, the RTs of DP were slower than those of SP. The similar tendency (DP > SP) was found in the low and no-experience groups regardless of the touch.

**Conclusion**

The results suggest that the mental imagery of the grasping, especially in the skilled climbers, seems to be mediated by the tactile input and the number of the holds. The tactile information of the hold may evoke the skilled climbers' representation of grasping a hold within a certain context related to a climbing movement. The number of the holds affected the time needed to prepare the climbing action (depending on the group and touch though), implying that the number of the visually presented holds can be represented as having a different complexity in motor preparation.

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**ASSESSMENT OF MOTIVES FOR ATTENDING AN ELITE SPORT SCHOOL – DEVELOPMENT OF A QUESTIONNAIRE FOR 9 TO 10 YEARS OLD MALE AND FEMALE ATHLETES**

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**Introduction**

Motives influence the motivation to initiate and maintain sport activities (Gabler, 2002). It could be assumed that the various motives determining the attendance of an elite sport school may have an impact on the later sports career. However, there are only few researches of young athletes' reasons to learn and practise at an elite sport school. Therefore, the aim of the study was to develop a questionnaire to

assess the explicit motives in question on the example of track and field athletes in order to determine, if these individual dispositions have long-term effects on the performance in elite sports.

#### Method

Fundamental to developing the questionnaire was the 2 x 3 motive taxonomy by Gabler (2002). Four items each collect data about a person-centred and social-centred perspective classified in (1) motives related to performing sport practice (2) motives related to the results of sport practice and (3) motives related to sport practice as a means for other purposes. The factorial validity of the instrument was examined using exploratory factor analysis on data collected from 233 young athletes ( $f = 103$ ,  $m = 130$ ) at the age from 9 to 10 years old who applied for the elite sport school in Magdeburg and Halle (Saxony-Anhalt, Germany).

#### Results

The exploratory factor analysis could not confirm the 2 x 3 motive taxonomy. After an item reduction a 2-factor solution with 8 items each was identified: factor 1 "gain recognition through practising athletics" and factor 2 "goal and purpose of practising athletics". Both factors make up 45.42% of the total variance. The KMO-coefficient is .891 ( $\chi^2 = 1137.57$ ;  $df = 120$ ;  $p < .001$ ). Internal consistency analysis revealed acceptable Cronbachs alpha coefficients (factor 1  $\alpha = .822$ , factor 2  $\alpha = .816$ ) with an inter-item correlation of  $r = .366$  and  $r = .319$ , respectively. The separation efficiency ranges from  $r = .365$  to  $r = .586$  (factor 1) and from  $r = .401$  to  $r = .692$  (factor 2).

#### Discussion

The adapted questionnaire seems to be an appropriate instrument for measuring young athletes' explicit motives for attending an elite sport school. Even if the talent selection of 9 to 10 years old track and field athletes is mainly based on the individual physical and athletic performance, the trainers will receive a self-assessment of the later elite sport school students. Studies show that children of that age are capable of coherent introspective reports (Sodan, 2008) and internalized self-assessments. Thus, results of the questionnaire provide information in the process of talent identification and for targeted interventions in talent development programmes in elite sport schools.

### **COGNITIVE IMPROVEMENT IN PATIENTS WITH NEURODEVELOPMENTAL DISORDERS AFTER A TARGETED PHYSICAL ACTIVITY INTERVENTION IN THE SCHOOL ENVIRONMENT.**

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#### ABSTRACT

The main objective of this study was to confirm the improvement of the cognitive function in children with a neurodevelopmental disorder after a targeted sports intervention that we found in a previous study 1.

Neurodevelopmental disorders involve impaired development of cognitive or motor functions manifest from childhood which can be inclined to lessen with increasing age 2.

In this work, we studied the effect on cognitive performance of a 6-week targeted physical activity intervention (2 sessions of 1 hour per week) at an approximate intensity of 60% -70% of  $VO_{2max}$ . The intervention sessions took place at the Manuel Siurot School in Seville. Participants were children aged from 4 to 12 years old.

A total of 21 children took part in the activity (intervention group) while other 17 children remained in class doing routine school activities (control group). Children of intervention group were also divided into two groups for the intervention sessions: children aged 4-7 years (10 children) and children aged 8-12 years (11 children). Children's quality of attention and sustained attention were assessed pre- and post-intervention using the Magellan Visual Attention Scale (EMAV 1 and 2, 3).

The Borg test was used at the end of each session to assess the effort perceived by children 4. The results of this test showed values according to a 60% -70% of  $VO_{2max}$  intensity.

A 2 x 2 mixed ANOVA with repeated measures revealed a significant interaction effect of time and group on quality of attention ( $F[1, 36] = 4.96$ ,  $p = .032$ ,  $R^2 = 0.12$ ). Pre- and post-intervention mean scores in the EMAV were  $33 \pm 5,86$  and  $25 \pm 4,27$ , respectively, in the intervention group, and  $16,23 \pm 3,33$  and  $25,70 \pm 5,50$ , respectively, in the control group.

Regarding sustained attention, both groups showed higher EMAV scores after intervention, with a significant main effect of intervention group ( $F[1, 36] = 17.48$ ,  $p < .001$ ,  $R^2 = 0.33$ ) and a non-significant interaction effect of time and control group on this variable ( $p = .817$ ). The improvement of sustained attention in the intervention group in comparison with the control group confirms a positive effect of sport on the physiopathology of the neurodevelopmental disorder. Therefore, school physical activity intervention could be used as a complementary therapy for neurodevelopmental disorders in children.

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### **SPORTS RULES ALTERATION IMPACT IN TAEKWONDO-SPECIFIC EXERCISE IN ELITE FEMALE FIGHTERS**

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#### INTRODUCTION:

Taekwondo is a martial art in which sport rules change dynamically. Recent amendments resulted in a rise in tournament combat intensity and longer post-combat recovery (1). Current research indicates that high-intensity interval training (HIIT) is effective in preparing professional Taekwondo athletes for new requirements (2). However, the forms of HIIT used are usually not discipline-specific. This study aimed to assess the kinematic and physiological response to Taekwondo-specific HIIT exercise compared to standard exertion until exhaustion.

#### METHODS:

In eight elite female Taekwondo athletes aged  $22.1 \pm 2.15$ , the exercise response to 197 Taekwondo-specific HIIT circuits ( $19.4 \pm 5.53$  circuits per athlete) was measured over one year. HIIT sessions consisted of 3 exercise sets divided into 3 series, each of 8 minute duration, with a 2:1 work to rest ratio. A bio-monitor (Bioharness™ 3, Zephyr Technologies, USA) was applied to obtain physiological and kinematic variables. Capillary blood samples were drawn before and after exercise for lactate (LA) concentration. Also, laboratory treadmill tests until

exhaustion were periodically performed to obtain reference ("maximal") values of cardiorespiratory variables. An analysis of variance for repeated measures was applied to reveal the differences between subsequent exercise sets.

#### RESULTS:

The average exercise intensity during the circuits was  $91.1 \pm 4.7\%$  of HRmax reached during laboratory tests. Several physiological and kinematic variables significantly increased from the first, through the second, to the third exercise set within one circuit session ( $p$ -values below 0.01). These were relative peak HR ( $92 \pm 5\%$ ,  $94 \pm 5\%$  and  $98 \pm 3\%$  of HRmax, respectively), energy expenditure ( $12 \pm 2$  kcal·kg<sup>-1</sup>·h<sup>-1</sup>,  $14 \pm 3$  kcal·kg<sup>-1</sup>·h<sup>-1</sup> and  $15 \pm 2$  kcal·kg<sup>-1</sup>·h<sup>-1</sup>), absolute LA concentration ( $7.5 \pm 1.9$  mmol·l<sup>-1</sup>,  $10.1 \pm 1.4$  mmol·l<sup>-1</sup> and  $11.4 \pm 2.9$  mmol·l<sup>-1</sup>), relative LA concentration ( $84 \pm 11\%$ ,  $102 \pm 17\%$  and  $122 \pm 19\%$  of LAm<sub>ax</sub>), peak mechanical activity ( $13.4 \pm 2.9$  m·s<sup>-2</sup>,  $15.4 \pm 1.9$  m·s<sup>-2</sup> and  $16.4 \pm 2.1$  m·s<sup>-2</sup>) and average mechanical activity ( $6.4 \pm 1.2$  m·s<sup>-2</sup>,  $7.0 \pm 1.1$  m·s<sup>-2</sup> and  $8.4 \pm 0.7$  m·s<sup>-2</sup>).

#### CONCLUSION:

The results prove that the Taekwondo-specific tasks in the form of a HIIT training result in a strong physiological and kinematic response to exercise. Such a training modality allows not only to reach an intensity close to that achieved during the exercise until exhaustion, but also to exceed it. It seems justified to incorporate high-intensity discipline-specific tasks into training regime to prepare elite martial arts athletes for very demanding real combat competition.

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### MULTIPLE-CHOICE AND CHOICE REACTION IN FEMALE AND MALE ATHLETES: DO WOMEN OUTPERFORM MEN?

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Introduction: Expert performance involves a combination of motor and perceptual-cognitive skills. Nevertheless, the role of general perceptual-cognitive abilities in sport and potential gender differences is not clarified in detail (Schumacher, Schmidt, Wellmann, & Braumann, 2018). The purpose of this study was to investigate the differences between female and male elite athletes in multiple-choice and choice reaction abilities.

METHODS:  $n = 89$  female ( $19.3 \pm 2.7$  years, age range 17 to 27 years) and  $n = 299$  male athletes ( $19.3 \pm 2.3$  years, age range 17 to 27 years) from 7 different sports (badminton, basketball, soccer, handball, hockey, judo, rowing) were included. The athletes in this study had been involved in organized sports for more than 5 years. Computer-based multiple-choice and choice reaction tests (using Vienna Test System) were performed. Group differences were analyzed using independent t-tests.

RESULTS: Significant differences between female and male athletes were observed, with regard to incorrect answers (female:  $16.1 \pm 9.2$ ; male:  $21.0 \pm 13.4$ ) in multiple-choice test ( $t(386) = 3.24$ ,  $p < 0.01$ ) and correct answers (female:  $15.1 \pm .4$ ; male:  $15.8 \pm .4$ ) in choice reaction test ( $t(386) = 1.1$ ,  $p = 0.04$ ).

CONCLUSION: Contrary to previous investigations (Dogan, 2009) our results indicate that female athletes have a lower total amount of incorrect responses in general multiple-choice reaction tasks. In the simple choice reaction test, male athletes outperform female athletes which is in line with previous literature (Chraif, 2013). In future studies, gender-related differences should be considered and discussed in the context of practical applications. Additional research is needed to further clarify age-related differences between male and female elite athletes.

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### MOTIVATIONAL FACTORS FOR PARTICIPATING IN A NORWEGIAN OUTDOOR EDUCATION PROGRAM

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Introduction: Norway have a well-known ingrained cultural tradition of being active outdoors (friluftsliv) deeply embedded in our identity, with strong grounds in the Norwegian Outdoor Recreation Act (1). Embedded in this tradition, the University of Agder offers a 30 ECTS-point course in friluftsliv, named Outdoor Education and Nature Guiding program (OENG). To be eligible to enter, students must apply with a personalized letter of motivation and a curriculum vitae related to outdoor activity. To evaluate, increase quality and to offer courses of high interest, it is important to understand students' motivational factors when applying. Therefore, the purpose of this study is to assess student's motivational factor when applying for the international outdoor education course.

Methods: Motivational letters from students during three courses ( $n=56$ ) in the period 2017 to 2020 were collected and analyzed using narrative text analysis. Arguments were systemized and categorized into 6 different motivational themes; 1) competence and/or profession, 2) Norwegian nature and friluftsliv-culture, 3) Personal development, 4) Friluftsliv in an environmental and sustainable perspective, 5) Friluftsliv in public health and 6) Other.

Results: In total, 177 motivational factors were identified. Of these factors, we identified that 77% of the students had competence and/or profession as one of their motivational reasons, 61% had Norwegian nature and friluftsliv-culture, 43% had self-development, 11% had friluftsliv in an environmental and sustainable perspective, 9% had friluftsliv in public health and 9% had others.

Discussion: Our results indicate that increased competence and self-development in relation to increased profession is the main motivational factor for students to participate in this course. This could possibly be due to most students are coming from countries outside Scandinavia, where outdoor education is more influenced by British and American tradition. However, the unique Norwegian friluftsliv culture, rooted in humbleness to nature is still a strong motivational factor for many students, and this factor are identical compared to national results in Norway (2). More surprising is that only one of ten students were motivated by an environmental and sustainable factor or public health, despite the increased focus and knowledge about the effects of climate change on nature as well as the importance of a more active lifestyle.

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## THE IMPACT OF PSYCHOLOGICAL SATISFACTION ON DEPRESSION AMONG JAPANESE ATHLETES

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### Introduction

Previous international studies suggest that depression rates among athletes range from 15.6 to 21%; this is equal to or higher than depression rates among the general population. If the psychological factors that strongly impact depression can be identified, then it will be possible to better educate athletes, coaches, and other staff. Therefore, the purpose of this study is to examine the effect of psychological satisfaction on depression among Japanese athletes.

### Methods

We collected data from 1,598 Japanese soccer players (1,437 men, 161 women; mean age = 17.72, SD = 2.02) who completed the following questionnaires: the Basic Needs Satisfaction in Sport Scale (BNSSS) and the Self-Rating Depression Scale (SDS). We then converted BNSSS scores into categorical variables based on the 75th percentile (into groups of "low" and "high"). SDS scores were converted into a dichotomous variable using a standardized cutoff (scores  $\geq 48$ ; we considered scores higher than this value to suggest moderate depression requiring clinical intervention). Using these categorical variables, we assessed the effect of psychological satisfaction in sport (independent variable) on athletes' depression (dependent variable) and performed a binomial logistic regression analysis.

### Result

Our correlational analysis indicated significant negative correlations between BNSSS subscale scores and SDS scores ( $ps < 0.001$ ). Sex and role (regular player, substitute player, or non-regular) were confounding variables; we therefore adjusted the logistic regression analysis. The adjusted analysis indicated that basic needs satisfaction scores were strong suppressive factors of depression (competence: adjusted OR 0.332–0.756; choice: adjusted OR 0.159–0.428; internal perceived locus of causality: adjusted OR 0.205–0.511; volition: adjusted OR 0.119–0.344; relatedness: adjusted OR 0.197–0.497).

### Conclusion

Our findings suggest that psychological satisfaction in sport is negatively associated with depression among athletes and that an athlete's competence, choice, internal perceived locus of causality, volition, and relatedness of psychological satisfaction may suppress depression. We propose that coaches and other staff pay attention to these factors in order to promote mental health among athletes.

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## EARLY SPECIALIZATION IN COMBAT SPORTS: AN EXAMPLE IN TOP-LEVEL KARATE COMPETITIONS

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### INTRODUCTION:

In recent years, early specialization in sport has been discussed among parents, coaches, and researchers as well. However, there is a lack of scientific data on this issue. Few studies show that early sport specialization in some sports is not a guarantee for later success in elite sport (1,2). Burnout and motivation loss are more prevalent within the youth sport setting, particularly with those who specialize in one sport in the very early stages (3). The issue of early specialization is also connected to the increase in functional disorders of the musculoskeletal system and injury incidence (4). High level of acidosis occurring during top-level kata performance (5) suggests that the energy cost required for training and competing when early specialized is inappropriate for youth. The aim of our study is to discover whether karate athletes in kata discipline in individual age groups compete with the same katas and might be at the risk of burnout, motivation loss or other early specialization issues.

### METHODS:

The kata performance in individual age categories (young cadets,  $n=229$ ; cadets,  $n=327$ ; juniors,  $n=241$  and seniors,  $n=551$ ) was compared in top-level male and female karate competitions. The relationship among the most used katas and all the age categories was determined. The normality of our data was checked through the Shapiro-Wilk test. The Chi-square test was performed to analyze if there are any statistically significant differences between observed variables.

### RESULTS:

Only 37 katas out of the overall number of 102 official katas in the World Karate Federation's list were performed during the analyzed competitions. We did not find any significant difference among age categories in the choice of kata  $\chi^2 (27, n = 1,956) = 24.50, p = 0.60$ . In the early stages, the technical drill and the great number of the repetitions of whole katas will probably perfect the kata, however, it may become tedious for young athletes and lead to „drop-out“ or loss of motivation. For this reason, it is not advisable to copy senior sports training at this age.

### CONCLUSION:

To prevent early specialization in karate and all the problems connected to it, we recommend distributing katas age-appropriately based on technical, athletic and physiological demandingness.

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**CP-SH07 Physical activity: Youth II****EDUCATIONAL INTERVENTION AND ITS EFFECTS ON THE BEHAVIOUR OF PUPILS WITH ADHD IN PHYSICAL EDUCATION**

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The purpose of research is to identify the conduct of pupils with ADHD by differentiating between desirable and non-desirable forms of behaviour; to describe educational interventions on the basis of the use of behaviour modification techniques in response to desirable and non-desirable forms of behaviour among pupils with ADHD; and to analyse the effect after educational intervention on the conduct of pupils with ADHD by assessing whether or not their behaviour changes after such intervention has taken place. The study is a multiple case study involving six Physical Education (PE) teachers and six pupils diagnosed with ADHD from the mid-grade (4th year) and higher grade (5th and 6th years) of Primary Education throughout one academic year. The researcher adopted the role of non-participating observer, using field notes to identify the behaviour of pupils with ADHD, to describe the educational interventions and to analyse the latter's effect on pupils' behaviour. Subsequently, the PE teachers were interviewed in order thus to complete the information gathered from observation. The quantitative data was subjected to descriptive and inferential analysis, and the qualitative data to content analysis of the narrative registers. Among the most striking results was the fact that 19% of forms of conduct were seen to be desirable, whereas the remaining 81% were perceived as non-desirable. Also observed were a total of 16% of educational interventions based on techniques aimed at enhancing or maintaining forms of behaviour (praise, attention, physical contact, rewards and privileges) and 84% of educational interventions based on techniques to diminish or eradicate forms of behaviour (differential reinforcement of low rates of behaviour [DRL], punishment, response cost, time out, directive instructions, interrogative instructions, informative instructions and extinction). The most important conclusions are the following: a) teachers should strive to create situations in which a greater number of instances of desirable behaviour are fostered (avoiding pupils' standing in line when it comes to carrying out an exercise, including explanations while the activity is under way, avoiding prolonged explanations of a new situation, controlling the duration of explanations, allowing pupils either to form part of the explanation, or else form part of the demonstration directed by teachers in class time, physical proximity between teachers and pupils when it comes to giving an explanation and so on); b) more frequent use should be made of techniques to enhance or maintain forms of behaviour; c) techniques of reinforcement or positive techniques (DRL) should be applied more often than punishment, extinction and instructions, since this study shows that they, too, are effective.

Keywords: ADHD, Physical Education, behaviour, educational intervention, effects

**PSYCHOLOGICAL HEALTH AND SUCCESS IN SPORT: INSIGHTS FROM ACADEMY ADOLESCENT ALPINE SKI RACERS**

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**INTRODUCTION:**

Elite performers often share similar psychological traits, such as mental toughness, grit, and intrinsic motivation. These traits impact how individuals approach training, competition and setbacks. Athletes' dispositions towards certain sports are largely formed during childhood and adolescence, and are speculated to be a product of how adversities are handled. Therefore, factors such as coping mechanisms and perceived expectations for success are paramount to mental well-being. In this investigation, we combine results from an extensive programme of work on adolescent ski racers to examine the psychological traits associated with ideal (e.g., good performance) and adverse (e.g., burnout) sport outcomes.

**METHODS:**

A large sample of adolescent alpine ski racers attending training academies in the United States (US) (N = 169, M age = 15.8 ± 1.3) and Austria (N = 209, M age = 16.6 ± 1.4) completed questionnaires assessing sport participation history and psychological dispositions. Performance data were collected with help from staff at US Ski and Snowboard through an online database.

**RESULTS:**

Ski racers in the US who began training and competing at a young age experienced greater parental pressure ( $p < .040$ ). Furthermore, ski racers with perfectionistic tendencies stemming from satisfying others (e.g., parent/coach pressure) were more likely to exhibit burnout ( $p < .028$ ). Burnout was associated with decrements in performance over time ( $p < .005$ ). In contrast, skiers who demonstrated self-driven strivings for success (i.e., perfectionistic strivings) showed greater performance improvements over time ( $p < .047$ ). Mental toughness, grit, and perfectionistic strivings were negatively correlated with burnout ( $p < .007$ ), while social support mediated (reduced) the effect of negative life stress on burnout ( $p = .011$ ). In comparing ski racers in Austria and the US, ski racers in Austria demonstrated less burnout, greater mental toughness, and greater grit than ski racers in the US ( $p < .007$ ). Additionally, females in the US reported the most parental pressure ( $p < .005$ ).

**DISCUSSION**

While we can sketch psychological profiles associated with success and mental well-being in adolescent ski racers, sources of stress will be unique to each athlete (i.e., based on upbringing, gender, culture, birth advantages, performance) and should be identified by coaches and practitioners to develop effective communication and training interventions. When athletes face adversity, perceived social support from mentors or peers will contribute to positive mental health for sport participation. Since a one-size-fits-all approach for athlete development cannot accommodate for the unique environmental stressors that athletes face, researchers should corroborate these findings from ski racers across domains and regions, and implement longitudinal approaches to better assess psychological development throughout youth.

**EFFECT OF A SCHOOL-BASED KARATE INTERVENTION ON ACADEMIC ACHIEVEMENT AND PSYCHOSOCIAL DIFFICULTIES IN EUROPEAN CHILDREN: A CLUSTER RANDOMIZED CONTROLLED TRIAL.**

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Background: Children's physical inactivity and its consequences on physical and mental health are a growing public concern but schools, and particularly physical education (PE) lessons, are considered key settings for promoting physical activity (PA) in this population. The aim of the present cluster randomized controlled trial was to examine the effect of a one-year school-based sport intervention based on the



Karate Mind and Movement program (i.e., a program including both basic and karate-specific motor skills) on academic achievement and psychosocial functioning in children aged 7-8 years.

Methods: Twenty schools of five different European countries participated in this study during the 2017-2018 academic year. In each school, two second-grade classrooms were randomly assigned to either a control group (habitual PE lessons, 2 sessions/week), or an intervention group (Karate Mind and Movement program, 2 sessions/week). Psychosocial difficulties and academic achievement were assessed at baseline and post-intervention by means of the Strengths and Difficulties Questionnaire (SDQ) for parents and students' average grades, respectively, and were analyzed using linear mixed models.

Results: A total of 721 children completed the study: 333 in the control group (161 girls, 7.4±0.4 years) and 388 in the intervention group (183 girls, 7.4±0.5 years). The Karate Mind and Movement program provided significant benefits over the control group on academic achievement ( $\beta=0.20$ , 95%CI=0.07 to 0.34,  $p=0.003$ ) and conduct problems ( $\beta=-0.41$ , 95%CI=-0.68 to -0.14,  $p=0.003$ ). However, no significant between-group differences were observed for the remaining SDQ subscales (i.e., emotional symptoms, hyperactivity/inattention, peer problems and prosocial behavior; all  $p>0.05$ ).

Conclusions: The inclusion of a one-year Karate school-based intervention provided benefits on academic achievement and conduct problems. Consequently, karate lessons may be a promising alternative to enhance relevant functions for learning and behaviour in primary school children.

### **STUPS – A SCHOOL- AND COMMUNITY-BASED APPROACH FOR PARTICIPATORY PHYSICAL LITERACY PROMOTION OF CHILDREN AND THEIR FAMILIES’ – A STUDY DESIGN AND DEFINITION OF PHYSICAL LITERACY**

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Introduction: The role of physical activity (PA) in the promotion of wellbeing and health amongst children is widely known. Research indicates that the time spent physically exercising and participating in organized sport activities decreases with age, in girls and children with a lower socio-economic status. Currently there is no gold standard to promote sustainable PA amongst vulnerable groups, however school-based interventions, particularly multi-component approaches and the promotion of physical literacy (PL), seem the most successful. StuPs –a Federal Ministry of Health funded project- aims to develop a community-wide approach to promote both PA and PL using schools as an access point to a target group of children and their families.

Methods: The first phase of the study includes a needs assessment and inventory in two social-deprived districts of Cologne (Germany, NRW). Via a mixed method design the status quo of existing offers, open space opportunities to move and play, present structures and networks will be analysed. Results will be used to identify existing needs and desires, as well as promoting and inhibiting factors of health promotion in the corresponding districts. A systematic literature research is conducted to define PL in a first step and an assessment of PL for children up to 10 years in a second. In the second phase an action plan to promote children's PA and PL will be developed based on the findings of phase one. This will be implemented in the following two years. To verify the effectiveness of the action plan, PL of children and parents will be analysed in a pre-post-comparison.

Results: Initial findings are based on the literature research of PL definitions. Corresponding definitions of PL vary in the current literature. Based on existing definitions summarized in a systematic review by Edwards et al. (2017) as well as the definition of the Canadian Assessment by Tremblay et al., (2018) a PL model for children and youth was conceived in this study. Therefore PL is understood as the interaction between all of the following four dimensions: (1) motor skills and abilities, (2) knowledge about health-, psychosocial-, emotional- and cognitive effects of movement, (3) motivation and self-efficacy, (4) participation in PA offers.

Conclusion: According to the current state of research, the PL approach is getting increasing attention. Achieving synergy effects between working groups focused on PL requires standardized definitions and methods to measure PL (Edwards et al., 2017). Next steps will focus on the research and development of appropriate methods to investigate the four defined dimensions of PL, also practicable in children aged 10 and younger.

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Tremblay et al., (2018) *BMC Public Health*, 18 (2), 1034.

### **INVESTIGATION INTO PHYSICAL ACTIVITY FROM A PEDAGOGICAL PERSPECTIVE BY USING THE ETHOLOGICAL MODEL**

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Introduction

Ethology is the branch of biology that deals with animal behaviour. The definition of behaviour is also a subject of debate among researchers, however, in order to understand the phenomena, it is usually sufficient to consider behaviour in the ordinary sense. The behavioural components of animals have traditionally been divided into two major groups: hereditary (genetically fixed) and learned. There are clearly inherited behaviours, but all learned behaviours have genetically fixed components, since the ability to learn is inherited. Analyzing data from all the behavioural elements of an animal can lead to the identification of causes and typing of behaviour.

In the field of Sport Sciences, among others, Hagger and Chatzisarantis (2016) began to use the "ethological approach" to describe the "correlates" and "determinants" of relationship systems that influence human intention, subsequent decision-making, and the resulting behaviour. Behaviour already means the incorporation of a certain pattern of habits into peoples daily lives, and this does not only imply the appearance of one-off action.

Material and method

As part of an international study, physical activity and motivation data were collected from  $n = 974$  primary and secondary school students (age group 11-18 years) from four countries (Hungary, UK, Slovakia and Romania) using a three-wave questionnaire survey.

Data were analysed by IBM SPSS v. 25 software package.

Results, conclusions

Our results showed that intention alone did not lead to the development and fixation of physical activity as a form of behaviour without the development of autonomous motivation in students. In addition, independent perceptions of behavioural control and past behaviors were the strongest determinants of the development of physical activity-related behaviour.

In conclusion, we recommend that practitioners, in addition to engaging in physical activity at a young age, focus on establishing the optimal group atmosphere/climate, both pre-school and school, through persuasive communication. In addition, in line with the above ideas,

the impact of the three social institutions (schools, families, peers) should be coordinated through targeted education and training. This is not an easy but a rewarding pedagogical task.

Keywords

Ethology, motivation, physical activity, pedagogy

Reference

Hagger, M., S. and Chatzisarantis, N., L., D. 2016. The Trans-Contextual Model of Autonomous Motivation in Education: Conceptual and Empirical Issues and Meta-analysis. *Review of Educational Research* 86 (2): 360-407.

## CP-SH08 Psychological and sociological perspectives on sport

### PERCEIVED LOCUS OF CONTROL PROFILES IN ATHLETES: RELATIONSHIP WITH ANGER AND HARDINESS

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The perception of locus of control, anger and hardiness are variables that have shown an important relationship with sport performance and other variables related with athlete's wellbeing. Therefore, the aims of the study were to identify locus of control profiles in athletes and examine whether participants from distinct profiles significantly differed on anger and hardiness. The sample was made up of 383 athletes (Mage = 28.14; SD = 9.42; 277 men and 106 women) that fulfilled a series of self-report questionnaires designed to measure: locus of control, anger and hardiness. Cluster analysis revealed two distinct profiles: (a) Profile 1, a low external locus of control profile, showing low scores on Academic Control, General Luck, Political Control, Interpersonal Control and Personal Initiative Success; (b) Profile 2, a high locus of control profile with high scores on Academic Control, General Luck, Political Control, Interpersonal Control and Personal Initiative Success. Results of MANOVA (Wilk's Lambda = .91,  $F(9) = 5.00$ ,  $p < .001$ ,  $\eta^2 = .99$ ) indicated significant differences across clusters on athlete's hardiness and anger. Results of follow up ANOVAs showed significant differences on temperament ( $p < .01$ ), reaction ( $p < .01$ ), internal anger expression ( $p < .01$ ), external anger expression ( $p < .01$ ), external anger control ( $p < .01$ ), anger expression index ( $p < .01$ ), commitment ( $p < .01$ ), challenge ( $p < .01$ ), control ( $p < .01$ ) and hardy personality general factor ( $p < .01$ ). Profile 1 reported the lowest anger levels and the highest hardiness levels. As a conclusion, two locus of control external profiles emerged from the cluster analysis, one characterized by a low level of external locus of control with high levels of hardiness; and another profile characterized by high external locus of control levels and with high anger levels and low hardiness. Also, cluster profile analysis can work as a strategy to order athletes at risk in order to make target intervention to reduce the levels of external locus of control.

### DOES SPORTS TRUST MEDIATE BETWEEN ORGANISATIONAL CITIZENSHIP BEHAVIOUR AND PATERNALISTIC LEADERSHIP IN YOUTH FOOTBALL TRAINING?

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Introduction

Leadership can significantly influence the organisational citizenship behaviour of employee (Tang & Naumann, 2015). Specifically, in the field of sports, leadership is associated with organisational citizenship behaviour (Mark, Richard, & Richard, 2008). Although the interrelationship between paternalistic leadership qualities and organisational citizenship behaviour has previously been established, it is necessary to determine if this relationship applies to youth football training. Trust plays a critical explanatory role that links paternalistic leadership to a variety of outcomes (Chang & Chi, 2007; Chen et al., 2014). In this study, we verify the mechanisms of paternalistic leadership applicable to youth football training.

Methods

A total of 312 youth football players were surveyed for the analysis. We chose to use published scales to test young athletes' perceptions of their coaches' paternalistic leadership, the trust of players in the coach as well as players organisational citizenship behaviours. Process control reduced the impact of common method deviations (i.e. anonymity, investigator's absence, multiple investigations, multi-site investigations and data analysis).

Results

Sports trust is significantly correlated with the paternalistic leadership of coaches. A significant negative correlation was observed between authoritative leadership and sports trust, whereas benevolent and moral leadership demonstrated significant positive correlations with sports trust in coach. By contrast, organisational citizenship behaviour was not significantly correlated with the three identified dimensions of paternalistic leadership (authoritative leadership, benevolent leadership, moral leadership).

Discussion

Our results of the effects of paternalistic leadership on sports trust are in line with those obtained in previous studies by Chen et al. (2014) and Kao, Hsieh and Lee (2017). In contrast to other studies that demonstrated the relationship between leadership and organisational citizenship behaviour (Mark, Richard, & Richard, 2008; Tang & Naumann, 2015), our results revealed no correlation between these parameters.

These findings suggest that managers should pay greater attention to the management and education of coaches. Coaches could be encouraged to avoid an authoritative leadership style and exhibit the characteristics of benevolence and moral leadership during the teaching process. To improve the leadership qualities of coaches, schools should strengthen their psychological education, show them relevant research results, and encourage them to recognise the negative consequences that result from authoritative leadership behaviours.

A colleague recommended that we should adjust our data. Our results, however, are based on the actual data analysis. We wish to investigate why our results differ so drastically from those obtained by other scholars. Interested scholars can contact us for more information.

## EXPLORING LEARNING STRATEGIES FOR CREATIVITY: A QUALITATIVE STUDY OF EXPERT ATHLETES UNLEARNING EXPERIENCES

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### Introduction

The Internet of Things (IoT) and artificial intelligence (AI) are changing the structure of society. Therefore, it is important to research creative human resources who can play an active role internationally in various fields (Runco, 2018). There are dangers that lead to "myth of creativity: creativity is due to the extraordinary talent of genius" (Weisberg, 2006) due to the bias toward genetic factors and personal characteristics, and the extreme emphasis on excessive professional education. Risks leading to social problems such as premature education and overemphasized learning experience have been pointed out (Sternberg, 2010)

The purpose of this study is to clarify how expert athletes experience creative activities in the process of acquiring exceptional performances. As a theoretical framework, we set the concept of unlearning, which brings natural thinking through flexible thinking. Based on this framework, the experiences and learning strategies related to the creativity of participants became clear.

### Methods

Participant selection was limited to expert athletes who had the experience of national team in Japan. Six athletes served as participants for this study. Their average age was 28.6 years old, and they had an average of 9.7 years of experiences as athletes. In-depth, open-ended interviews were conducted with each athlete. Interviews ranged between 60 to 90 minutes, were recorded with the permission of the participants. The interviews were thoroughly transcribed verbatim immediately after the completion of each interview, and total of 162 meaning units were extracted from the data set. The data was decontextualized using an inductive procedure for analyzing unstructured qualitative data (Côté, Salmela, Baria, & Russell, 1993).

### Results

The inductive analysis process resulted in regrouping these interview transcripts into three categories (elimination of preconceptions, openness to the experience, and meta-cognitive understanding).

### Discussion & Conclusion

Results of the current study suggested that three variables influenced the building of a unlearning experiences as a development of creative expertise. All of the participants faced a lot of problems and built up their unsuccessful experiences throughout their athletic activities. Consequently they realized the needs of continuous self-change for their performance enhancements. Evidence of the athletes' mental conflicts to the learning strategies also surfaced throughout the training and the game.

This study found significant agreement between the perceptions of the concepts on how athletes evaluated their learning activities in relation to performance enhancement and how this support affected their development of creative excellence. The strong relationship between three categories indicates that athletes direct themselves to commit to unlearning as a way of constructing the creative mental model.

## CP-SH10 Assessment and validation

### IS SELF-REPORTED FITNESS USEFUL FOR ESTIMATING OBJECTIVE FITNESS LEVELS IN PEOPLE WITH SEVERE MENTAL ILLNESS? THE PSYCHIACTIVE PROJECT.

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#### INTRODUCTION:

Severe mental illness (SMI) is a leading cause of disability and mortality worldwide. The unhealthy lifestyle that they present contributes to an accelerated deterioration of fitness, and consequently, an increased risk of death from any cause [1]. The poor of viability, availability and training by professionals makes it difficult to assess the fitness quickly and efficiently. The self-reported questionnaire "International Fitness Scale" (IFIS) [2] is a validated tool in healthy and clinical populations that allows estimating fitness. The aim was to study the validity of the IFIS questionnaire in people with SMI.

#### METHODS:

A cross-sectional study was conducted in 177 adults ( $n = 50$ , 18-65 years) with SMI. Participants completed the IFIS questionnaire and objective fitness tests. The IFIS consists of 5 items to assess the level of fitness and its components (cardiorespiratory fitness, strength, speed and agility and flexibility) using a Likert scale (from very poor = 1 to very good = 5). A composite fitness score was constructed by averaging the standardized values of its 4 components. The agreement between the self-reported and objective fitness was analysed, as well as the differences in the objective fitness between the categories of the questionnaire.

#### RESULTS:

No differences were found between the self-reported and objective measures for fitness and its components ( $p < 0.05$ ). We obtained the same results when analysed by adjusting by sex, age, duration of illness, medication and severity of symptoms. Subjects who reported a good/very good fitness in any item, had better objective fitness for this item compared to those who reported as very poor /poor.

#### CONCLUSION:

IFIS seems to be a valid tool to estimate the fitness in adults with SMI. In addition, it allows identifying people with poor levels of fitness, who require a priority intervention to improve their health through physical exercise programs.

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## DEVELOPMENT AND VERIFICATION OF THE EFFECTIVENESS OF A PATIENT-BASED EATING ACTIVITY QUESTIONNAIRE TO ASSESS DISABILITIES WHILE JOB HUNTING

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### INTRODUCTION:

When employing people with disabilities, the evaluation of various functions is necessary. For example, the evaluation of upper limbs' function is essential for desk work. Upper limbs' function involves various factors including range of motion, dexterity and muscle strength. Therefore, it is important to evaluate function based on patient-centered approach, especially focusing on activities of daily living (ADLs), which can assess patients' function as a whole. We focused on eating behavior, which is an ADLs task, as a way to evaluate patient function. While eating, we use tools, and ingest various sizes and shapes of food using multiple body functions. Thus, it is possible to estimate patients' upper limbs' function by evaluating their movements while eating. For this reason, it is possible to properly evaluate the functions of people with disabilities by evaluating their eating behavior, and their employment can be appropriately chosen depending on their functional level. In this study, we developed a questionnaire on eating behavior so as to evaluate the upper limb function of people with disabilities and aimed to verify the effectiveness of evaluating their employment and productivity.

### METHODS:

The subjects of the study were several pre-employment people with disabilities who attended vocational schools. The questionnaire was self-reported. We estimated the association of the questionnaire with the Fugl-Meyer Assessment (FMA). Reliability of the questionnaire was assessed by test-retest reliability. Validity was evaluated using a correlation analysis. This study was approved by the ethics committee of Kyoto University.

### RESULTS:

Sixteen people participated in the study. The intraclass correlation coefficient was 1.00 for the right arm, 0.869 for the left arm, 0.994 for the right hand, 0.883 for the left hand, and 1.00 for the trunk. The correlation between the questionnaire score of the hand and the FMA score of the wrist/hand was  $r=0.746/0.847$ . It was  $r=0.858$  between the score of the arm in the questionnaire and that in the FMA.

### CONCLUSION:

This developed questionnaire was reliable and significantly related to clinical evaluation of upper extremity function. Further evaluation of the questionnaire, including the development of a various job matrix based on the assessment by the use of this questionnaire is warranted.

## TRANSFER OF RESPONSIBILITY QUESTIONNAIRE (TORQ) TRANSLATION AND VALIDATION INTO A SPANISH UNDERGRADUATE CONTEXT

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PABLO DE OLAVIDE UNIVERSITY

### INTRODUCTION

The TPSR (Teaching Personal and Social Responsibility; Escartí, Pascual y Gutiérrez, 2005; Hellison, 2003; Hellison y Martinek, 2006; Lee y Martinek, 2009) is an educational model to promote the positive youth development and has been used for more than three decades (Hellison y Walsh, 2002). While research supports the effectiveness of TPSR in promoting responsibility in physical education and teaching SEL competencies (i.e., life skills), the examination of transfer is underdeveloped (Wright et al., 2019).

The purpose of this study was three-fold: (1) to create a "Transfer of Responsibility Questionnaire (ToRQ)" Spanish version; (2) to analyse the psychometric properties of the Spanish version of the "Transfer of Responsibility Questionnaire (ToRQ)" that we have called instrumento de transferencia de responsabilidad (ITR); (3) to analyse the transference of responsibility after a pedagogic adventure model intervention in undergraduate context.

### METHOD

The participants were undergraduate students of Sport and Physical Activity Sciences bachelor's degree and Elementary School Education bachelor's degree at Universidad de Sevilla. It was used the Spanish version of the ToRQ, called "ITR": (1) motivación para su uso; (2) expansión de las percepciones; (3) valor experiencial. For the validation, the first step was an evaluation of the understanding and concordance with the intention of the original tool by three experts on the field work using a likert scale (5 points); the second step was using the ITR to evaluate transference of responsibility in an undergraduate context.

### RESULTS AND CONCLUSIONS

The results revealed, on the one hand, that the validity and reliability of the Spanish version of the ToRQ were satisfactory. On the other hand, the students showed a great transference degree after the intervention using a TPSR and Adventure Education based program.

KEY WORDS: transfer of responsibility, ToRQ, validation, questionnaire

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## EXPLORING EFFECTIVE FOOTBALL PASS PREDICTION ALGORITHMS USING MACHINE LEARNING AND POSITIONAL RELATIONS

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### INTRODUCTION:

In football matches, the quality of passes between players has a great impact on teams' performance, and key passes can directly result in goals opportunities. Although passing behaviors have been extensively studied, predicting the receivers of passes still need to be addressed so as to refine on-field collaborations and inform tactical decisions. With the development of machine learning, researchers can analyze massive passing data along with players' positional information to acquire a deeper understanding. Therefore, the study was aimed to

apply different machine learning algorithms into the prediction of passing behavior from professional football players and compare the efficiency of all models.

### METHODS:

The publicly available data where 14 matches of a Belgian team in the 2014-2015 season were obtained. It consisted of 12,124 passes, 2D coordinates (x/y) of all players on the field for each pass, the passer's and receiver's numbers. Afterwards, pass prediction models were built to predict the candidate receivers according to following algorithms: i. Football Pass Prediction (FPP), assuming players would prefer forward passes to backward passes; ii. Light-GBM, a gradient boosting tree framework; iii. The Random Forest and Decision Tree. To train the classifiers, the pass-related features related to between-teammate and between-opponent distances and neighboring player numbers were extracted from players' positional data. A 10-fold cross-validation was used to build and evaluate the result, and the top-1, top-3 & top-5 candidate receivers were compared against the actual receivers to get the prediction accuracy.

### RESULTS:

It was shown that those algorithms differed a lot in prediction accuracy. The FPP's result for top-1 was 31.76%, higher than random prediction (7.88%). The accuracy for Light-GBM in predicting top-1, top-3 & top-5 receivers was 41%, 70% and 81%, and 51%, 68% and 78% for Decision Tree with 555 nodes. Finally, the Random Forest yielded higher accuracy, with top-1, top-3 & top-5 being 80%, 88% and 92%. Meanwhile during training the classifier, we found that features with high weight were related to the candidate receiver's position, such as a receiver's distance to the closest opponent, the absolute value of the y-axis between the passer and a receiver and a receiver's distance to the passer.

### CONCLUSION:

The FPP model was too simple to be applied for real matches and had the lowest accuracy. The Light-GBM model was more complex by using multiple features and a gradient boosting tree framework, but its accuracy was similar with that of the Decision Tree model in top-3 and top-5 receiver prediction and lower in top-1 prediction. The Random Forest produced the best prediction accuracy in top-1, top-3 or top-5 receiver. Finally, it was implied that on-field position of pass receiver and opponent's distance to him conditioned the quality of the pass and the Random Forest could be effective when modeling pass behaviors within practical performance analysis scenario.

## CP-SH11 Sports in international contexts

### FASTER, HIGHER ... COSTLIER? KEY FACTORS FOR COST CHANGES OF OLYMPIC STADIUMS FROM SYDNEY TO PYEONGCHANG.

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Recently Olympic Games have been used as a catalyst for urban improvements, e.g. expanding public transportation, developing new city districts and constructing new dwellings (Chalkley & Essex, 2006). However, most drafts for improving urban developments are often changed in the further course of planning and implementation resulting in higher costs (Preuß, Andreff & Weitzmann, 2019). Primarily, Olympic stadiums are associated with cost overruns. This may not be surprising since Olympic stadiums have always been one of the largest constructions at Olympic Games. Further, Olympic stadiums are the venue of opening and closing ceremonies and therefore, can be seen as flagship of the Olympic Games. The aim of the study is to identify key factors that have led to cost overruns at Olympic stadiums in the past and gain insights how to avoid cost overruns in future.

Olympic stadiums built between 2000 (Sydney) and 2018 (PyeongChang) are considered on the basis of the same IOC requirements for stadiums. A qualitative document analysis based on secondary data from the time of bidding to staging the Games was used. In order to obtain reliable results, official documents and credible reports were established as selection criteria. For this, 10 candidature files, 9 official reports, 12 scientific articles, 4 grey literature, 39 newspaper articles and 20 information websites of stadiums, architects or cities were selected.

1. The most common cause for rising costs is the extension of stadiums that are not required for hosting (e.g. Salt Lake City, Athens, Turin, Beijing, Vancouver, Sochi). 2. Selecting unsuitable sports facilities lead to higher costs especially at Olympic Winter Games. Not having a fixed concept at planning stage lead to the redesign of stadium (e. g. Beijing, London, PyeongChang). 3. Delayed construction starts impacted the construction costs (e.g. Sydney, Athens, Beijing). 4. Poor estimates were also a problem (e.g. Sydney, London). 5. Corruption was identified as a factor for higher costs only in Sochi. However, it cannot be ruled out that this has not led to higher costs at other stadia as well.

The results show the importance of having binding concepts. In order to counteract past sources of error, better planning is necessary. Estimations must be made with the support of knowledge transfer from past or similar projects. This helps to avoid many failures caused by selection of sports facilities, poor estimates, extensions and redesign of stadiums and poor time management. Likewise, it must be ensured that it is not possible for parties involved to enrich due to construction work on the stadium. Introducing stronger performance controls may therefore be useful to minimize or even eliminate future cost overruns.

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### INVOLVEMENT AND EVALUATION – AN INTERNATIONAL SPORTS EVENT FROM THE PERSPECTIVE OF THE RESIDENTS OF A HOST CITY

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Introduction: Despite the programs facilitating the organization of international sport events announced by the IOC, 6 cities withdrew from the Olympics and also Budapest joined to this group in 2017. In the same year, Hungary organised major international and national sports events - such as the 2017 Water Sports World Championship, the European Youth Olympic Festival (EYOF), with 10 different sports - at a world class level and successfully exploited their tourism-related potential.

In the past Olympic period, a total of 109 and in 2017 over 100 international sports events have been organised in Hungary with state support. With the increase of the number, size and coverage of these events, the required financial and infrastructure investments, social impacts, the number of stakeholders and the extent of their involvement have also grown in Hungary. Interestingly, the social support for

international sporting events has bottomed out. In this trend, the growth of the impacts on the population of the host city, may play a key role.

As one of the most important success criterion of international sports events is social support, the question arises that how social support can be achieved? How the residents of the organizing city form an opinion about the impacts of an international sports event? The study answers these questions by analysing the case of the EYOF in Győr.

Methods: In the empirical research, both qualitative and quantitative methods were used. The online questionnaire focused on attitude questions, which were asked in 8 question groups. Residents opinions on international sports events were asked both before and after the event. The "pre" questionnaire was filled in by 806 subjects, while the "post" questionnaire by 703 people. This means a total of 1,509 questionnaires. In 172 cases, subjects filled out both the pre- and post-event survey, therefore this section of the sample functions as a panel database. Data are representative for gender, age and education. Regression models were built on the basis of the results obtained by factor analysis, nonparametric tests, cluster analysis and linear regression analysis.

Results: The results show that a general positive opinion about international sports events is positively connected to a high level of sports consumption (both spectator and participation sport). Also, those who are personally satisfied with their life quality generally support the organisation of international sports events and have a positive opinion about such events' impacts. The level of satisfaction with life is correlated with being satisfied with the city and having a positive opinion about the city's services. The regression model showed that the level of involvement (e.g. interest, participation, volunteering) is positively related to the evaluation of the impacts of the sports event. The higher the level of involvement is, the more people have a positive attitude to and are enthusiastic about the event.

### **LOST IN THE CLEAVAGES: THE FOUNDATION AND EVOLUTION OF THE SUPREME COUNCIL FOR SPORT IN AFRICA, 1965-2013**

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In July 1965, members of the Permanent Committee for the First African Games from diverse backgrounds met in Congo Brazzaville three days to the games and subsequently discussed the formation of a supranational sport organization in the continent. The Supreme Council for Sport in Africa (SCSA) was formally constituted in Bamako in 1966 and in 1977 assumed the status of an agency of the Organization of African Unity (OAU) now African Union (AU), until its dissolution in 2013. The SCSA is remembered most for its fight against "discrimination" in sport, instigation of the boycott of the 1975 Montreal Olympic Games and the main host of the African Games. Based on interpretive hermeneutic historical enquiry, archive materials from the IOC Historical Archive in Lausanne and the Supreme Council for Sport in Africa Archive in Yaounde were analysed for a better understanding and interpretation of the identified cleavages in which the SCSA operated. An organization's discourse is embedded in the intended and expressed meaning in its documents. The historical enquiry provided evidence that though the SCSA was not founded as a supranational governmental agency in sport: subsequent divergent positions with the IOC on the role of international sport and lack of a clear cut vision was not able to detach it from Africa's political, economic and social dilemma. The SCSC was not able to reconcile the different structural colonial legacies that also reflected in the sport setting. Internal leadership challenges and different interpretations that are given to sport and its function in society further hampered the execution of its main aims. The African Union Social Commission has since 2013 decided to create an alternative organization, the African Union Sport Council with little changes to the structures and mode of operation of the SCSA. Transnational sports organizations, therefore require a deeper understanding of the fragile stage that reflect the structural realities of the society on which they operate. AU (2013), Gadamer, H. -G. (1975)

### **REGULATION OF THE PROFESSION OF A SPORTS COACH IN COLOMBIA AND SPAIN**

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Regulation of the profession of a sports coach in Colombia and Spain

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Introduction

In Colombia and Spain, in the last 10 years, efforts have been made to regulate the profession of a sports coach, a very complex task, especially since the requirement of qualification degrees is only possible, by the decision of the legislative body of each country or of the national sports federation, a product of the application of the guidelines that come from the international federation, as it happens in soccer or athletics, as an example.

Methods

It corresponds to an investigation of comparative law, which includes the following sources of law: the Political Constitution of Colombia and Spain, the Colombian and Spanish legislation, the constitutional jurisprudence of Colombia and Spain.

Results

Article 26 of the Political Constitution of Colombia expresses the free right of people to choose their profession; it also expresses the social risk in an indeterminate way; the concept is developed by the Constitutional Court. In Spain, constitutional protection is somewhat more limited, in line with the legal reserve to regulate professional associations and the practice of professional graduates, provided for in article 36. In both Colombia and Spain, the completion of certain qualifications to practice these professions, including that of coach, is based on protecting the right to health and safety of users of sports activities. Thus, this work establishes that both the Colombian and the Spanish regional legislators have validly defined the activity of coach as a profession, for which the requirement of suitability titles is constitutionally admissible, protecting the general interest of congruence with the principle of human dignity as a fundamental right.

Discussion

In the case of Colombia, the social risk is present in the training process, because it meets three conditions: (i) it is of considerable magnitude, concerning its capacity to affect the general interest and fundamental rights; (ii) it is susceptible to control or substantial decrease with specific academic training; (iii) has the purpose of preventing the awkward exercise that may produce harmful effects. In Spain, it is through article 36 where a role is reserved for the legislator to regulate professional colleges and the exercise of titled professions; its connection with Directive 2006/123 / EC, of the European Parliament and the Council, on services in the internal market; that is, the right of sports users to health and safety in physical and sports activities. It is very important to clarify that in Spain there are regional laws, autonomous communities have autonomy to do it; in Colombia, there are only national laws. The truth is that sport occupies

## **THE CONNOTATION, JUDGMENT AND CLASSIFICATION OF SPORTS DIPLOMACY : BASED ON THE PERSPECTIVES OF REALISM AND LIBERALISM**

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Sports diplomacy with its uniqueness as processing problem between countries, easing contradiction between countries, an important means to promote the relationship between countries. Judging from the current results of domestic sports diplomatic research, there are many problems with the definition of sports diplomacy. The research results on the nature and value of diplomacy at home and abroad are summarized: First, the essence of diplomacy is the official nature of the subject, the policy instrumentality, and the peace of manner. The second is that diplomacy deals with international relations, but diplomacy is not international relations. Third, diplomacy is one of the many means to implement national foreign policy. Fourth, diplomacy is based on international law and other international norms, and safeguards national interests in peaceful ways such as communication and negotiation. Fifth, the value of diplomacy is not simply to resolve specific conflicts. In many cases, it is to help or promote mutual understanding between various actors in order to reach an agreement between them.

From the perspective of historical practice, sports diplomacy is an important path and way to promote world peace, cultural exchanges, and sports globalization, and is an important driving force for the development of world sports events. From the perspective of realism and liberalism, this paper makes an in-depth study on the connotation, judgment and classification of sports diplomacy. The research believes that sports diplomacy contains both realism and idealism, and its essence is a kind of political practice. To this end, we define sports diplomacy as the embodiment of a country's diplomatic strategy in the sports field. Sports organizations and institutions communicate and explain the target country or international relations issues with the purpose of promoting friendly relations between countries, expressing political positions, transmitting relationship information, safeguarding the interests of the community, and defending the concept of international morality, Sum of mechanisms and policies.

The classified perspectives of sports diplomacy include: (1)Political Alliance. (2) Economic Cooperation. (3) Cultural Exchanges. (4) Safeguarding World Peace and Justice. To judge whether a sports exchange is sports diplomacy, we have summarized four criteria: one is subjectivity, the main body of foreign exchange is the official or representative official. The second is strategic, with clear diplomatic goals and plans. The third is targeted, sports diplomacy is an activity that targets specific objects within a specific time. The fourth is public relations. The theme, process and goal of the event are highlighted as a public relations activity.

## **A SPORT MARKETING RESEARCH: UNDERSTANDING THE IMPORTANCE OF NEW MARKETING TOOLS AND TECHNIQUES IN THE CONSUMPTION LEVELS OF CONTENTS OFFERED ON SOCIAL CHANNELS**

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### **Introduction**

With the emerging developments in technology, new marketing tools and techniques of digital marketing are also advancing in sport marketing. As being two examples of these new techniques, content marketing and content creating are tools that form the future of digital marketing [1]. With the help of social channels, professional clubs, elite players and federations can easily be accessed by sport consumers [2]. The present study aimed to examine the level of consumption and consumers' reaction to types of content offered by football clubs and their respective social channels regarding digital marketing in sports sector.

### **Methods**

In this research, ten professional football clubs were analysed including Premier League, La Liga, Serie A, Bundesliga and Ligue 1 which are considered to be the top 5 football leagues in Europe, where two clubs from each league were chosen. The determination of clubs was based on the popularity rates on social channels. Firstly, it was decided that the statistics of YouTube, a type of social channel, will be used to obtain the data to be analysed within determined criterion. Then, the clubs were separated with respect to eight different types of contents they generate on this platform and the average viewing rates of contents within up to date and predetermined time periods were established. Finally, the consumption levels were analysed in compliance with the types of contents developed.

### **Results**

The results suggest a significant difference from the standpoint of highlights content, among the Premier League and other four leagues. However, although clubs' own contents (produced for social channels) have higher viewing numbers than news, no significant differentiation has been observed when comparing the total viewing rates among all content types offered through Youtube.

### **Discussion**

In today's digital era, the evolving process of sport marketing has changed the way clubs and athletes reach to sport consumers. However, it would not be accurate to say that federations are totally benefitting from the potential of marketing in digital field. Among the top 5 leagues being examined, since Premier League is the only one to have distinctive broadcast marketing strategies, it could be proposed that the level of contents they offer on social channels are higher than the level of highlights consumption (view rating) when compared to other leagues. The research also indicates that, although consumers show more interest in contents created for themselves on social channels, the fundamentally consumed product is still football. Finally, it could be asserted that, creating and marketing the right contents on social channels in the future, will be demanded as much as the main product football. Hence, suggesting that this could affect the federations in developing alternative strategies for marketing their broadcast rights.

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## **THE POSSIBILITY OF USING SPORTS AS POLITICAL TOOLS: CONSIDERATION BASED ON THE CRISIS OF SPORTS EXISTENCE**

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### **Introduction:**

It is understandable that sports should be free from political interventions. However, it is also a fact that sports are an integral part of the broader society and political or moral decisions inevitably influence sports. This research considers how much sports can be separated

from other living-spheres, whether or not sports should be used as political tools which promote different normative values, and if so, how to make such decisions.

Methods:

Survey previous researches in the field of sports psychology and consider the relationship between sports and politics historically and psychologically.

Result and Discussion:

In this research, "sports" mean those competed in at the Olympic Games and World Championships. Sports are regarded as one of the peculiar worlds set apart from ordinary society by differentiating people based on "particularly defined areas" and this is possible in a liberal society with guaranteed freedom of association.

It has been the case for years that politics, economics, culture and religions have all made use of sports in various ways. The ancient Olympic Games were religious festivals in Greece and contributed to the existence of Ancient Greece. Folk football in Medieval Europe took different forms, but people often played it on Shrove Tuesday or during the Easter festival, which helped maintain communities in towns and villages and kept parishioners together. European soccer has been used by religions and social classes. Boycotting in the Moscow Games (1980) and the Los Angeles Games (1984) were typical cases of the Olympic Games having been affected by the politics of the East-West Cold War. What should be the relationship between sports and politics in the future? Sports are turning into something only wealthy people can do and re-examining the modern society and sports further, it should be pointed out that conditions and environments for sports are under threat. Peace is a prerequisite for sports, but political disorders jeopardize this. Environmental problems also put sports in danger. Countermeasures against intense heat have been discussed for the Tokyo Olympic Games and global warming, air pollution, marine pollution, etc. are not only crises for sports but also for humanity as a whole. What is necessary to do sports are assurances of peace and comfort (physically, economically and time-wise) and that there are no environmental problems. Without them, no one can do sports. Sports, therefore, are expected to contribute to retaining daily comfort and stability.

Sports require an ordinary society and environment. However, everyday life is more important than sports for most people. We should use sports to improve certain aspects of people's lives. Sports can be a way forward.

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## THE BURDEN OF ANTI-DOPING PROMISES

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Since the 50s and the first anti-doping rules in the 60s (Dimeo, 2007; Gleaves & Hunt, 2016), the Olympic movement shaped an anti-doping doxa (Bourdieu, 1977). In our communication we would like to understand, through a sociological gaze, how this doxa changed with the creation of the WADA and what is the outcome of it.

Method

We realised a content analysis of 24 issues of the Olympic Review, based on a sample of 4 years before and after WADA's creation (1988, 1999, 2004, 2016), of 4 official declaration of the IOC conference on doping (1999, 2003, 2007, 2013) and of 35 issues of Play-True, the official newsletter of the World Anti-Doping Agency from 2002 to 2015.

We also rely on the analysis of the 2015 "Russian crisis", before and after the Rio games, through a sample of 1143 papers on doping that were selected issues newspapers, website, Facebook, tweeter, collaborative network, official communication. And we had partial access to the backstage of anti-doping.

Results

Parallel to the promise of a "technology-based detection regime" (Meier & Reinolds, 2018) and the belief in science, sport organisations promised to win the battle of anti-doping. The Olympic movement staged the laboratories as the solution to win the battle. Later, the athlete biological passport (ABP), introduced in 2009 "was seen by some as the saviour of clean sport" (M. Daly, BBC Scotland Investigations Correspondent, BBC, 4 June 2015). The WADA contribute to shape a strong orthodoxy on the condition in which a performance can be judged as legitim. Although discourses and promises changed, instead of winning the battle, it was promised to defend "clean sport" and to protect the "clean athletes", the 2015 crisis highlighted the gap between the promises and the recurrence of scandals in doping. Despite some effective changes in the doping culture (Ohl, 2019), the promises became a burden difficult to manage for sport organizations. Our analysis shows that the anti-doping orthodoxy created expectations that are impossible to achieve. As a consequence, it increased the mistrust in anti-doping and the tension among sports stakeholders. As a consequence, we recommend a less orthodox position on anti-doping, as it can be the case for other legal regulations in society.

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## CP-SH12 Coach education and risk management

### EXAMINING THE ROLE OF RELATIVE AGE AND SELF-REGULATION WITHIN A PROFESSIONAL FOOTBALL ACADEMY

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Introduction:

The recruitment and development of players within professional football academies is big business. As such, understanding the characteristics of players who progress to professional level may have implications for effective talent identification and development processes. Previous research has suggested that current performance is often used as a proxy for 'future potential' in football (1). This is exemplified by what is known as the 'relative age effect' (RAE), where those born early in the selection year often dominate academy programmes due



to performance advantages related to maturation. However, the relationship between performance at youth and senior level has been shown to be poor. A growing body of work has highlighted the role of psychological attributes in the realisation of future potential such as the ability to self-regulate ones learning (2).

Aims:

1. Examine the relationship between relative age, recruitment and coach perceptions of high potential in a professional football academy.
2. Examine the relationship between self-regulation, coach perceptions of high potential and progression within a professional football academy.

Methods:

Ninety one male youth football players (14.80 ± 21; U12–U18) were recruited from an ‘elite’ professional football academy in Scotland. Participants completed a demographic questionnaire and the football specific version of the Self-Regulated Learning–Self Report Scale (3) (planning, reflection and evaluative behaviours). Perceptions of future potential were collected from the Academy manager. Progression was determined by whether a player was re-signed or released from the academy at the end of the season.

Data Analysis:

Perceived potential and progress were combined to form four categorical variables; deselected, progressed with low potential (LP), progressed with average potential (AP) and progressed with high potential (HP).

Results:

Descriptive statistics revealed a RAE bias for those recruited to the academy: Q1= 40.65%, Q2= 30.77%, Q3= 20.88%, Q4= 7.69%. However, no additional RAE was apparent between those perceived to have higher and lower potential. With regards to self-regulation, a statistically significant difference was found between deselected, LP, AP and HP groups for evaluative skills ( $p = 0.012$ ,  $np2 = 0.142$ ). Effect sizes show overall self-regulation of learning ( $p = 0.125$ ,  $np2 = 0.077$ ), reflection ( $p = 0.138$ ,  $np2 = 0.074$ ), and planning ( $p = 0.475$ ,  $np2 = 0.034$ ).

Conclusion:

The results suggest that recruitment is influenced by relative age, however, the perceptions of potential within the academy cohort is not. As such, the criteria used for identifying talent between different staff may be incoherent. Furthermore, those with higher levels of potential engaged more in key self-regulation skills, particularly evaluation. This study presents preliminary evidence of the importance of self-regulation.

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### DO COACHING SKILLS FOR PROMOTING LIFE SKILLS DEVELOPMENT IN PLAYERS RELATE TO BEING A GOOD COACH?

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Introduction

Japan Sport Association introduced the model core curriculum for nurturing certificated coaches based on “Seven Recommendations to be a Good Coach” (RGC, Ministry of Education, Culture, Sports, Science and Technology (MEXT), 2015). Previous research (Holt et al., 2009) showed that coaches influence the development of life skills (LS) in players both positively and negatively. There is a lack of research that shows the relationship between being a good coach as presented in RGC and coaching skills for promoting the development of LS in players.

Methods

The survey was conducted in August and November 2019 using “Sports Coaching Skills Scale” (Shimamoto et al., 2015) and 53 coaches of various sports (44 males and 9 females) completed. This scale evaluates coaching skills that promote the development of LS in players. It covers 4 factors: coaching skills for promoting visualization of practical process (VPP), appreciating others (AO), spontaneous behaviors, and achieving goals (AG). Also, participants answered the degree of paying attention to each item of the RGC by percentage. Items of RGC are as follows: to eradicate violence and any types of harassment (RGC1), to enhance coaches’ “human skill” (RGC2), to keep learning (RGC3), to consider players as the first priority (RGC4), to nurture independent players (RGC5), to make efforts to be open-to-society coaches (RGC6), and to enhance coaches’ social trust (RGC7) (MEXT, 2015).

Results

The results of a Pearson’s correlation analysis showed that there were moderate positive correlation significantly between VPP and RGC5 ( $r = .42$ ,  $p < .01$ ), and RGC6 ( $r = .47$ ,  $p < .01$ ), AO and RGC6 ( $r = .44$ ,  $p < .01$ ), AG and RGC4 ( $r = .47$ ,  $p < .01$ ), and RGC5 ( $r = .43$ ,  $p < .01$ ), and total scores and RGC5 ( $r = .44$ ,  $p < .01$ ), and RGC6 ( $r = .53$ ,  $p < .01$ ).

Discussion

The findings indicated that some factors of coaching skills for promoting LS development in players have the potential to be related to items of RGC. The positive correlation between total scores of coaching skills and RGC5 showed the validity of the data because LS help athletes to be independent. Also, the correlation between 2 factors and RGC6 showed that coaches might need to be open to society to enhance players’ various experiences with people outside sports teams. In conclusion, enhancing coaching skills has the potential to lead coaches to be aware of RGC in their daily coaching.

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### COACHING, PLAYER DEVELOPMENT AND DELIBERATE PRACTICE

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INTRODUCTION

Studies of expertise show that in order to be skilled in a domain a person must be engaged in Deliberate Practice (DP) (1) as well as having a supportive environment (2, 3). Most DP-studies, not the least in sports, focus on adults and on individual skills with one-to-one coaching. Open questions are still how to design learning environments that promote DP and the development of skilled performance. Furthermore,

how DP-coaching can be carried out in team sport settings and how coaches can provide individual, quality feedback and more specifically, how video can be used. Questions like these have been studied in a well-known "soccer academy" (IFK Göteborg), where young female and male athletes train football with an attempt to become skilled football players.

#### METHODS

Using a design-based approach, where a traditional training method, called S2S, was developed on the basis of DP-principles, we have carried out two studies. One was focusing on a "team skill" – passing angles – and conducted with boys born 2007 (n=15). The other was an individual skill – shooting with the instep – and was conducted with girls born 06-07 (n=17). In both studies the athletes participated in two 30 minute "DP-sessions" on a weekly basis during a 10-week period.

Mixed methods were used for data collection; observations and video-recordings of practices and games, interviews with players and coaches, and measurements of performance outcomes (number of passes during a match and shooting speed, respectively). Using a multi-theoretical approach (DP-theory, motor learning theory, and socio-cultural theory) we have analyzed both the performance of the athletes and the coaching environment.

#### RESULTS

We found significant improvements of the two skills practiced during our 10 weeks intervention. Girls shooting velocity increased substantially during the 10 weeks of training and three months after the study was completed, the effect still remained. The boys, who were coached performing passing angles, also increased their competency in performing this skill significantly.

Furthermore, from our qualitative data we note that the individuals commitment and a supportive environment always interact. Therefore, the coach has a vital role and must be engaged, active, and supportive and give lots of quality feedback. The players, on the other hand, express clearly that they are focused, committed and want to be the best. Therefore, they spend lots of time and effort to improve.

This project has enhanced the understanding of how DP can be orchestrated and enacted in successful learning environments and coaching practices.

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### **CONSTRUCTION, VALIDATION AND APPLICATION OF AN OBSERVATION SYSTEM IN A PILOT STUDY ON THE OFFENSIVE PROCESS IN WOMENS FOOTBALL**

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*ESCOLA SUPERIOR DE DESPORTO DE RIO MAIOR*

#### INTRODUCTION:

The development of football has provided new challenges for coaches in terms of team preparation (1). The evolution and development of the match requires coaches to constantly update their knowledge about the players and the teams where they work (2). Based on this paradigm, a pilot study was carried out, applied to three teams from the Liga BPI (1st division of womens football in Portugal), during the 2018/2019 season, with the goal of characterizing the offensive process of these teams.

#### METHODS:

The elaboration of the study was based on the conceptual assumptions of the methodology of observation (3) for the construction of the ad hoc observation instrument called the Observation System for the Offensive Process in Football (SOPOF). Following the validation steps, the instrument was refined using the expertise of three experts and the analysis of intra-observer reliability using the GSW7 software, where Cohens kappa coefficient was applied. Subsequently, the pilot study was applied in a total of 6 games (2 games per team). The sample consisted of 893 actions (average of 148.8 per game). For the data's treatment was used the software VideObserver for game analysis.

#### RESULTS:

There was a 98% value in the intra-observer analysis. The results of the pilot study indicated that the greatest number of offensive actions in the game occur between 76 and 90 minutes (20%). When the offensive process was started by running ball, 23.7% was the result of interception to the opponent. The throw-in was the most relevant set pieces in the start of offensive process (21.2%). The right side in the offensive midfield is the area where the greatest number of ball recoveries occurs (16%). During the creation phase, the right side of the offensive sector was the most requested area to transport the ball to the finishing area (27.6%). The central aisle was the most requested in the finalization phase (71.2%). The most recurring finishing action was the shot out with a total of 40.1% of the shares. Analysing the success in the construction phase, only 17.7% of the actions were successful, with the partial success criterion being privileged with 53%. In the creation phase, success was also not the most recurrent (30.4%), with the failure criterion totalling 45.2%. Checking the change in the result, 60% of the actions were carried out when the teams was winning.

#### CONCLUSION:

The observation system analyses the actions related to the offensive process through 4 criteria, 22 sub-criteria and 145 categories, which reveals that the instrument is efficient efficient in relation to the purpose for which it was developed. The application of the pilot study allowed to characterize the offensive process of each of the three teams, thus revealing possible trends for this phase of the game in womens football.

### **DAILY PHYSICAL ACTIVITY HAS DIFFERENT ASSOCIATIONS TO RATING OF SUBJECTIVE TRAINING EFFORT IN YOUNG SWIMMERS COMPARED TO ADOLESCENT SWIMMERS**

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#### INTRODUCTION:

Perceived exertion during and after swimming training has been in recent focus [1,2]. Decreases in overall physical activity (PA) levels in children and adolescents have taken place [3] and also for those taking part in sport trainings, less free time PA is present [4]. Different amounts of free time PA might also have the effect for the ratings of perceived training effort (RPE) and consequently, for internal training load. The aim of this study was to examine associations between young swimmers' rating of perceived effort of swimming training and daily physical activity.

#### METHODS:

Eighteen (mean age 12.3±1.2 years; 8 girls, 10 boys) young group and eight (mean age 16.0±2.1 years; 2 girls, 6 boys) adolescent group national level swimmers participated. Sedentary behavior and PA were measured by ActiGraph GT3X accelerometer (ActiGraph LLC, Pensacola, FL) with 15-second epochs. Each participant was asked to wear the monitor on the right hip for 14 consecutive days, except when sleeping, or in conditions the accelerometer could get wet. Sedentary time, moderate- to vigorous physical activity (MVPA) were calculated. For 2 weeks, all training bouts were recorded, RPE was asked 30 min after the session [5] and internal training load was calculated.

### RESULTS:

No differences were found in average RPE values and total training load of the two weeks period between two groups ( $P < 0.05$ ). Adolescent group spent more time in being sedentary compared to young group ( $513.3 \pm 7.6$  vs  $474.1 \pm 6.5$  min/day;  $P < 0.05$ ) after adjustment for sex and wear time. While no difference was found in MVPA between the two groups ( $P > 0.05$ ). Multilevel association model showed that vigorous PA ( $P = 0.45$ ) and MVPA ( $P = 0.037$ ) were negatively associated with RPE values after the training in young group, while sedentary time ( $P = 0.001$ ) and MVPA ( $P = 0.003$ ) were negatively associated in adolescent group.

### CONCLUSION:

The amount of free time PA has the influence on post training subjective effort rating in young and adolescent swimmers. Higher MVPA was associated to higher ratings of RPE in young group, while the association was negative in adolescent group.

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## KNOWLEDGE TRANSFER FROM SPORT SCIENCE INTO PROFESSIONAL FOOTBALL AND VICE VERSA – A METHOD APPROACH

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### INTRODUCTION:

Exchange of knowledge between sport science and professional sport is essential for performance optimization. However, a cooperation is challenged by connecting time-consuming scientific research with the fast-paced working routine in professional sports (Coutts, 2016). Recently, Brink et al. (2018) report coaches' interests on integrating scientific knowledge in daily football practice. Lack of time, linguistic incomprehensibility as well as poor practical applicability have been identified as main reasons for an insufficient use of scientific knowledge. Personal interaction between scientists and professional club representatives often emerged as a preferred way to transfer knowledge (Brink et al., 2018, Reade et al., 2008). Thus, we wish to present such outline.

### METHODS:

To benefit from consecutive information and data exchange, scientists alongside with representatives of a German Bundesliga football club developed a customized process to provide applicable scientific knowledge transfer. Project managers on either side established a tailor-made digital platform using a questionnaire to submit research questions, its origin and the existing knowledge level. Scientists assess and, if necessary, specify the research request. Subsequently, literature is reviewed resulting in a comprehensible summary, accessible for all cooperators on the digital platform. If needed, scientists are available for personal instruction upon request. Additionally, scientists permanently identify and provide relevant knowledge proactively. Initially, a workshop was held to familiarize both scientists and club representatives with the project.

### RESULTS:

This approach aims to implement a consistent and prolific exchange between scientists and representatives of a professional football club. The club benefits from a supply chain featuring latest scientific findings to optimize its performance output, whereas the scientists benefit from accessing highest competition levels for accompanying research projects. Thus, not only (young) elite players' data is gathered but hands-on hypotheses can be derived for applied research in the future.

### CONCLUSION:

While consistent quality management seems as necessary as helpful to evaluate scientific and practical benefits of such projects, an institutional separation of the university and the club will serve maintaining high levels of working output and quality.

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## EVALUATING OBSERVATION AND ASSESSMENT COMPETENCIES IN SPORT-SPECIFIC MOVEMENTS: A METHOD APPROACH FOR STUDYING PHYSICAL EDUCATION AND COACHING IN SPORTS

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### INTRODUCTION:

Observation and assessment competencies are crucial prerequisites for a successful and goal-oriented practical teaching process of physical activity (e.g. assessing the quality of a movement performance; Hodges & Williams, 2012). In addition, goal-oriented feedback to the individual performing a movement requires the ability to verbalise the movement observation (i.e., movement description) and, if necessary, precisely address appropriate movement corrections (Knudson, 2013). Accordingly, observing and assessing sport-specific movements are essential when educating future movement educators (e.g. students becoming physical education teachers and sports coaches). In a first step, this study aims to investigate underlying mechanisms in novice movement educators assessing an observed sport-specific movement and subsequently verbalising (i.e., describing) its performance, based on the use of terminology as well as on recognizing and naming possible causes of uneconomic movements (e.g. movement errors).

### METHODS:

Prior to the participants' swimming, track and field or gymnastic classes, video sequences were presented to 201 volunteering students (age  $21.3 \pm 2.2$  years, 117 male, 84 female, semester  $1.9 \pm 1.2$ ) via an online questionnaire. The tasks were to (1) give a comprehensive description of the movement, (2) identify and name possible movement improvements (i.e., movement corrections) and (3) specify one main aspect of improvement. The selection of sport-specific movements includes basic, acyclic movements from swimming (i.e., kick-off, start jump), track and field (i.e., sprint start, long jump) and gymnastics (i.e., handstand, cartwheel) complemented by a cyclic movement for swimming (frontcrawl) and track and field (i.e., sprinting). Young competitive athletes ( $n=4$ ) served to perform high quality task-1-movements in their respective sport, in order to create a consistent internal norm for the subsequent tasks 2 and 3. All movements for tasks 2 and 3 were performed by school children ( $n=2$ ) with little sport-specific movement experience.

**RESULTS:**

Our findings from a preliminary qualitative content analysis will form the basis for deriving and systemising basic observation and assessment mechanisms in movement educators (i.e., students).

**CONCLUSION:**

Based on our findings, we wish to discuss a subsequently intended comparison of the students' competency levels to expert observation and assessments mechanisms in the respective sports, to eventually develop practical teaching measures as well as examining opportunities that help improving the education of future physical education teachers and sports coaches.

**Literature**

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## CP-SH13 Professional development and educational settings

### PREFERRED SOURCES OF KNOWLEDGE IN GRANADIAN RUGBY COACHES

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25th Annual ECSS Congress Sevilla/Spain, June - July 2020

Preferred sources of knowledge in Granadian rugby coaches

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**INTRODUCTION**

An increasing body of research has explored how sport coaches learn and develop [1]. In particular, the value of social learning approaches initiatives has gained credence in the literature [2]. In this regard, research related to how coaches learn concludes that coaches most often learn from other coaches and has shown that coaching collaboration is essential for boosting educational innovation and coaching improvements [3]. However, insight into the fundamental dimensions that underpin coach learning in rugby could be more comprehensive [4]. Therefore, the current study aimed to explore rugby union coaches' importance in the ongoing training, their perception on coaches' collaboration as a method of acquiring new coaching knowledge, and their preference methodology in formal coaching courses.

**METHODOLOGY**

This project utilized a single case of study design involving a group of 22 rugby coaches from Granada (Spain) currently involved in competition. The method included the administration of a validated questionnaire QUGRAFOR [5] that passed a Delphi study through rugby training experts following a double review [6]. The process resulted in the revision of the different items and the final survey was comprised in 7 questions which were Likert scale closed-answer. The reliability of the instrument obtained through the Cronbach index for the responses of the coaches was ( $\alpha$  0.78) [7] which shows a good consistency between the proposed items.

**RESULTS**

The analysis of the descriptive data revealed 81% of the survey were men coaches and 18% women. Findings also show that most coaches consider the importance of updated knowledge (73%) and the common use of coaches' collaboration in order to acquire knowledge (strongly agree 40%). All coaches indicate that usually exchange experiences with other coaches, and most of them (68%) pointed out that collaboration in working groups where the preferred learning method in formal coaching courses developing knowledge about individual and collective technique and tactic and systems of play.

**CONCLUSIONS**

Taking into consideration collected data, it seems important to promote discussion groups that engage both coaches and other professionals on a regular basis to officially exchange/share ideas and information in order to gain coaching knowledge and experience. Also due to the low use of reading books and magazines among coaches, it also would be beneficial to offer coaches opportunities to learn how to search the literature properly.

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### EARLY DROPOUT FROM SPORTS AND STRATEGIC SKILLS IN SCHOOL: A CROSS-COUNTRY STUDY IN ITALIAN AND SPANISH STUDENTS

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Early dropout from sports activities is an important phenomenon in youth, which contributes to sedentariness later in life. While the search for factors associated with dropout rates is ongoing, the relations between those factors, including skills that have a strategic value in performance and life domains different from sport, are still under-investigated<sup>1</sup>. The aim of this study was to analyze the association between early dropout and strategic functional skills relevant to both sport and academic career, controlling for the individual and joint role of nationality, gender and age.

The sample consists of Italian ( $N=261M$ ; 172F) and Spanish ( $N=111M$ ; 83F) students aged 14-18 yrs. They completed two self-assessment questionnaires concerning: a) physical and sports activity habits (CAPAFD)<sup>2</sup> and b) strategic skills in the affective-motivational and cognitive-metacognitive domains (QSA)<sup>3</sup>. The study was performed with a mixed-methods (qualitative/quantitative) design.

Results of frequency analysis showed effects of nationality, with greater dropout from sports for Spanish as compared to Italian students ( $\chi^2 = 13.69$ ,  $p < .001$ ; 23.4% vs 11.7%) and gender, with larger dropout of females than males ( $\chi^2 = 6.35$ ,  $p = .012$ ; 19.75% vs 12.29%), but not age ( $p = .123$ ). Most importantly, the higher the number of critical values in affective-motivational strategic skills, the higher the frequency of students who drop out of sports ( $\chi^2 = 13.83$ ,  $p = .008$ ; 8.3% vs 14.4% vs 19.7% vs 22.2% vs 29.4% in students with none to all critical values). Instead, cognitive-metacognitive skills were non-discriminant for sport dropout rates ( $p = .797$ ). Moderation analysis showed that strategic skills are associated with dropout rates independently of gender and age, but interactively with nationality. Moderation analysis also showed a lack of persistence in the same (individual/team) sport type being predictive of higher dropout rates, but only in males.

This study suggests that: 1) affective-motivational competences relevant to sport and non-sport life domains may play a role in preventing dropout rates; 2) cultural and personal characteristics, skills and sports habits may independently, but also jointly contribute to the phenomenon of dropout. These interrelations must be considered to develop targeted prevention strategies.

Key words: Dropout, sport practice, life skills, affective, motivational, cognitive, metacognitive.

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## CONTRIBUTION OF SPORT GAMES IN PE TOWARDS REACHING RECOMMENDED PHYSICAL ACTIVITY LEVELS

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UNIVERSITY OF VIENNA

### Introduction

The World Health Organisation recommends that children are active in moderate or vigorous intensity for at least 60 minutes per day (WHO, 2010). Schools play an important role in reaching these goals since children spend a considerable amount of time there. The Austrian curriculum includes two to four hours of physical education per week. Besides other educational objectives, PE classes usually provide students with the chance to be physically active. A popular way of engaging physical activity are sport games (cf. Raab, 2019). This study investigated the contribution of sport games in PE towards reaching recommended physical activity levels.

### Methods

A total of 95 students aged 13 to 14 participated in three PE lessons with a focus on sport games (basketball, soccer, "Völkerball" / German dodgeball). Each lesson included a game phase lasting 10 to 15 minutes. Heart rate and speed were recorded using a heart rate monitor and a footpod (Rath, Kolb & Dobiasch, 2018). Based on average heart rate and moving time students were categorised into one out of three clusters using k-means clustering.

### Results

The mean game duration was 13:30 minutes. On average 20% of the students were assigned to the lowest cluster, where the average moving time was 5:30 minutes and the average heart rate was 146. In the other clusters the average moving time was around nine minutes.

### Discussion

The analysis showed that for some students the selected sport games did not significantly contribute to recommended levels of physical activity, as they did not reach a moderate intensity zone during the games. Consequently, the function of sport games as part of PE needs to be evaluated critically in order to attain desired physical activity levels among students.

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# E-poster not debated

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PP-UD01

## BIOMECHANICS

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### QUIET STANDING POSTURAL SWAY OF BIATHLETES

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#### INTRODUCTION:

Biathlon is a specialized sports discipline combining two elements, exhaustive physical exercise (skiing) and a task that requires high concentration and precision (shooting). Meticulous analyses of shooting position, especially of its stability, indicate that postural balance is a key element of shooting effectiveness, which determines the outcome of the entire biathlon competition [1, 2].

The aim of the study was to examine and compare the postural balance of 11 biathletes (6 female and 5 male; mean age: 19.5±1.7 years), and 12 physically active, untrained subjects (7 female and 5 male; mean age: 22.8±1.6 years).

#### METHODS:

Postural balance was examined using the Zebris FDM-2 Force Distribution Measuring System, which records the COP (center of foot pressure) signal. Postural balance was evaluated in two conditions: (1) standing barefoot with eyes open and (2) standing barefoot with eyes closed.

During each postural balance measurement, the participant remained still on the platform, with the arms in front of the body. Each postural balance measurement lasted 40 seconds. The first and last five seconds of each recording were removed and the 30-second records of COP displacements were further analyzed.

#### RESULTS:

The “group” factor did not significantly affect the parameters describing the COP shifts. In both groups, eye closure caused a significant increase in sway path length ( $F=13.37$ ;  $p=0.0007$ ) and average velocity of COP ( $F=12.62$ ;  $p=0.0009$ ).

For surface area of COP, the level of statistical significance was recorded for the “group” and “vision” factors. Athletes were characterized by significantly lower values of this parameter than the control group ( $F=14.88$ ;  $p=0.0004$ ). In no-vision conditions, an increase in surface area of COP was observed in both groups ( $F=6.36$ ;  $p<0.0155$ ).

#### CONCLUSION:

The study showed that quiet standing posture was more stable among biathletes compared to the non-athletes. A significantly smaller surface area of COP in biathletes is probably the result of specific postural adaptations developed in the process of long-term training.

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### KINEMATICS ANALYSIS OF THE ROUNDHOUSE KICK ACCORDING TO ATTACK ANGLE IN TAEKWONDO

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#### INTRODUCTION:

Taekwondo is a full contact combat and one of the kicks most used in competition is roundhouse kick directed to the thorax (1). In combat, the actions of opponents are unpredictable, it is crucial for an athlete to be able to use modified roundhouse kicks in response to different target angle to compensate for any evasive moves of the opponent. To generate enough impact energy to score points on electronic protectors, powerful and accuracy of kick are important factors that help in achieving victory. Therefore, the aim of this study was to analyze joint kinematics of the kicking leg by roundhouse kick in different attack angle on electronic body protector.

#### METHODS:

An EBP (Daedo) was used for the experiment. Eight male black-belt taekwondo athletes perform five roundhouse kicks at three different attack angle (90°, 60°, 30°) were defined and marked on the chest protector. Motion Analysis System with 8 Eagle Digital Camera (Motion Analysis Corp., Santa Rosa) at 200 Hz was used to record the joint kinematics of hip, knee, ankle during the kicking phase. One trials with the highest inductive value were chosen for further analyzes.

#### RESULTS:

The results revealed a significant difference in maximum hip flexion angle, abduction angle and maximum knee flexion angle. Comparative analysis within three different attack angle for hip. Maximum flexion angle 90° < 60° < 30°, maximum abduction angle 90° > 30°, 60° > 30° attack angle. Maximum knee flexion angle 90° > 60°, 90° > 30° attack angle.

#### CONCLUSION:

In the present study, we analyzed joint kinematics of the kicking leg by roundhouse kick in three different attack angle on EBP, with the evidence showing that hip flexion angle, abduction angle and knee flexion angle, may play an important role increased the foot segment to generate enough impact energy to score points on electronic protectors.

**THE EFFECT OF PROLONGED CYCLING ON THE OUTPUT OF THE LOWER LIMB MUSCLE GROUP**

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**INTRODUCTION:**

In long distance cycling competitions, maintaining and improving cycling speed to suit the circumstances are important factors. As such, it is necessary to both increase endurance in the circulatory organ as well as efficient muscular output. There is a large volume of prior research relating to cycling movements however there is little study into the output of the lower limb muscle group from the relationship with actual prolonged cycling and the simulators often used for training, etc. In this study, we measured the myoelectric potential of the lower limb during long-time cycling and compared the difference in muscle exertion between actual cycling and simulated cycling to obtain basic knowledge on teaching long-term pedaling.

**METHODS:**

The subjects are 3 males experienced in cycling and 3 males inexperienced in cycling. They belong to the cycling club at the same university. In the actual trial, the subjects rode their bicycles on undulating roads used by professional cyclists for practicing. In the simulation trial, a cycle simulator was used, and trial times were 60 minutes for both groups. In both trials, the subjects rode in their daily posture, and the subjects pedaled at speeds of their choice. Subjects cycled while looking at the heart rate monitor in order to maintain a heart rate of approximately 80% of their previously measured maximum heart rates. The surface electrical potential of a total of eight muscles - the tibialis anterior, gastrocnemius muscle, abdominal medial muscle, lateral vastus muscle, rectus femoris, biceps femoris, gluteus maximus, and gluteus medius muscles - was measured for 10 seconds every 5 minutes for a total of 12 times.

**RESULTS:**

In the latter half of the trial, experienced subjects used more of their hip extensors such as the gluteus maximus and gluteus maximus, while the inexperienced subjects used more of their knee extensors such as the vastus medialis and the vastus lateralis. Also, in the simulation trial, the amount of time of the muscle group of the lower limb used decreased.

**CONCLUSION:**

In extended cycling, in comparison with the inexperienced subjects, the experienced subjects did not use more of their muscle in the first half of the trial, but did use more of their hip extensors such as the gluteus maximus and gluteus maximus in the second half of the trial.

**JUMPING PERFORMANCE IS NOT RELATED TO SKATING SPEED IN ICE HOCKEY PLAYERS**

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**INTRODUCTION:**

In professional sports different vertical jumps are used to monitor performance as well as for conditioning purposes. Squat jump (SJ) has been shown to be appropriate for evaluating off-ice leg power potential in elite ice-hockey players. This study was designed to determine the asymmetry of SJ propulsion and SJ landing impact loads and whether they are related to execution quality and on-ice or off-ice performance.

**METHODS:**

Four-teen competitive male ice-hockey players (age: 20-34 years, BMI: 21-31 kg/m<sup>2</sup>) with playing experience of 14-30 years volunteered to participate in this cross-sectional study. After a brief warm-up on a stationary bicycle and ten seconds vertical foot tapping activation, squat jumps were executed on a 0.52 x 0.60 m pressure platform with about 1900 sensors (FDM-J0.6SQ, zebris Medical GmbH, Isny, Germany). The vertical ground reaction forces (GRF) were obtained at a sampling rate of 120 Hz. Three maximum effort SJ trials with one practice attempt without countermovement were performed. Jumping height (h) was calculated from flight time. The quality of the technical execution was quantified as the amount of decrease in GRF (countermovement, CM in % body mass) before propulsion. The force-time profiles of the two SJ with minimum CM were selected. Inter-session reliability of h was excellent (ICC 3,1=0.95, SEM=1.1 cm). Thus, the trial with the maximum h was used for further analyses. Propulsion (PP) and landing (LA) peak forces are given in times body weight (BW) for left (L) and right (R) sides separately. The amount of asymmetry was calculated by 100-(minimum/maximum x 100). Linear skating speed (30 m) with and without puck were recorded with timing gates (DLS-LA Timing System, AF Sport, Wesel, Germany). Possible systematic effects were explored using effect size (d) and Pearson's r statistics.

**RESULTS:**

Athletes' mean h was 28.7 cm (19.6-36.0). The amount of CM was 11.5% on average. PP revealed moderate differences between sides (L: 1.13 BW, 0.95-1.40; R: 1.17, 1.01-1.39; d=0.56). LA, in contrast, showed comparable mean peak values (L: 1.96 BW, 1.19-2.71; R: 1.92, 1.15-2.74; d=0.05). However, skating speed with (4.67 s, 4.44-4.93) and without (4.53 s, 4.33-4.79; d=1.1) puck showed large differences. Large PP (5.5%, 0.7-18.6; d=1.1) and LA (25.7%, 4.0-50.2; d=1.7) asymmetries were found. However, the amount of asymmetry could not be related to any performance measure (h: r < 0.34, p > 0.23; skating speed: r < 0.45, p > 0.11). Interestingly, the magnitude of CM was not related to h (r = 0.15, p = 0.61).

**CONCLUSION:**

Substantial unilateral peak forces with meaningful asymmetries could be proven in a bilateral task. Since landing with higher peak forces has the potential to damage musculoskeletal structures, prevention strategies should not only focus on force absorption but also consider individual compensations. To reduce the forces during landing, the athlete's attention can be drawn to the sound at landing.

**CENTRE OF PRESSURE EXCURSION IN ACROBATIC GYMNASTICS PYRAMIDS WITH DIFFERENT LEVELS OF DIFFICULTY**

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**INTRODUCTION:**

The static maintenance of the pyramids is essential for the final performance in acrobatic gymnastics. Greater difficulty in the pyramids increases the final score (1). Associations between the centre of pressure (CoP) excursion and the judges scores were found during the execution of simple initiation pyramids (2). Higher displacements of the CoP have been observed with increasing difficulty of balance tasks (3, 4). It may be expected that CoP excursion increase in pyramids of greater difficulty. This study compared CoP excursion and judges score between pyramids of different difficulty level.

**METHODS:**



Twenty-four acrobatic gymnasts ( $n = 12$  pairs) performed five trials of back pyramid (low difficulty-LD) and a handstand pyramid (high difficulty-HD) on a force platform. In LD pyramid, the top gymnast is supported on the feet at two points by the hands of the base and support on the collarbones. In the HD, the top gymnast executes a handstand position supported exclusively by the hands of the base gymnast. Pyramids were held for 7 seconds and surface area, range, medio-lateral amplitude and antero-posterior amplitude of the CoP were examined to analyse balance. The pyramid scores were obtained from qualified judges. Medians of successful trials and 95% confidence limits of each pair were computed for all the measured variables. The Wilcoxon test compared LD and HD pyramids. Significance level ( $p < 0.05$ ) and effect size were obtained.

**RESULTS:**

Higher scores were achieved in the LD compared to HD pyramid ( $Z \leq -2.93$ ,  $p < 0.05$ ,  $ES = -0.9$ , large). These differences in performance were also observed in the CoP excursion ( $Z = -2.93$ ,  $p < 0.05$ , effect size  $= -0.9$ , large). Higher values in area, range and amplitude parameters were observed in the HD pyramid compared with LD pyramid.

**CONCLUSION:**

The HD showed higher CoP excursions and lower scores compared to LD. CoP monitoring could help coaches and gymnasts to assess the pyramid instability.

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### **INFLUENCE OF FOOT PROGRESSION ANGLE ON KNEE ADDUCTION AND FLEXION MOMENT DURING STAIR DESCENT IN HEALTHY INDIVIDUALS**

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**INTRODUCTION:**

It has been confirmed that toe-in and toe-out modifications reduce the knee joint load during walking and stair climbing<sup>1-3</sup>. There are few reports, however, have focused on stair descent, which requires a higher load than walking and stair climbing. Patients with knee osteoarthritis have more pain and difficulty with stair descent than with walking, stair climbing and sit-to-stand movements, suggesting that a reduced mechanical load on the knee joint during stair descent might contribute to improving performance and quality of life. The purpose of this study was to investigate the effect of foot progression angle on knee joint load and related variables during stair descent.

**METHODS:**

Twenty-two healthy young adults performed a stair descending task at predefined speed (90 steps/min) with normal foot progression angle (normal), toe-out ( $15^\circ >$  normal) and toe-in ( $15^\circ <$  normal). Three-dimensional motion analysis was performed. The ground reaction force with three components, center of pressure positions, and sagittal and frontal plane hip and knee joint kinematic and kinetic variables were recorded during stair descent. The stairs consisted of two steps placed on a force plate. The height of the first and second steps were 16.5 cm and 33.0 cm, respectively. The treads of the steps were 40 cm. Ground reaction force data from the first step were used for kinetic analysis.

**RESULTS:**

The first and second peak medial ground reaction forces were smallest to greatest (and significantly different) in the order of toe-in, normal, and toe-out. There were no significant differences among the three conditions for the first and second peak vertical ground reaction forces. The center of pressure positions at the peak of the knee adduction moment were most medial to most lateral in the order of toe-in, normal, and toe-out. During the stance phase, the peak external knee adduction moment during the toe-out condition was significantly decreased by about 20% compared with the normal condition ( $d = 0.30$ ) and by about 23% compared with the toe-in condition ( $d = 0.37$ ). In contrast, the peak external knee flexion moment of the toe-in condition was significantly increased compared with the normal and toe-out conditions (normal vs. toe-in,  $d = 0.46$ ; toe-out vs. toe-in,  $d = 0.51$ ).

**CONCLUSION:**

The toe-out condition successfully reduced the peak knee adduction moment, which is related to the contact force in the medial compartment of the knee joint. On the other hand, the toe-in condition increased the peak knee flexion moment compared with the normal and toe-out conditions. These results indicate that toe-out is the most advantageous strategy for reducing the knee joint load during stair descent, especially in the medial compartment of the knee joint.

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### **COMPARATIVE ANALYSIS OF THE TEMPORARY DISTRIBUTION OF THE PHASES OF DISCUS THROWING AT THE 2017 IAAF WORLD ATHLETICS AND THE SPANISH AND CATALAN ATHLETICS 2019**

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**INTRODUCTION:**

The objective of this study is to compare the temporal distribution of the different phases of discus throw (1) in competitions of different levels, such as the 2017 IAAF World Championships in London, from which the biomechanical studies carried out by the University of Leeds has been taken as a reference (2), the Spanish Championship 2019 and the Catalan Championship 2019. With the results obtained from this comparison, I try to establish whether there are big differences between throwers who participate in world championships and national level athletes in the temporal distribution of the phases. And, if that's the case, to see if the phase where there is a greater difference is the aerial phase.

**METHODS:**

The analysis of the temporal phases of both national championships was performed by recording multiple throws and studying them subsequently with the Kinovea program (version 8.15). Altogether, 137 throws were analyzed, 75 belonging to the Spanish Championship and 62 to the Catalan Championship, with a total of 60 athletes observed (30 female and 30 male). These results were compared with the

study of the 2017 IAAF World Championships in London, which analyzes the best throw of the competitors in both championship finals with a valid mark and, therefore, implies the analysis of 23 attempts (11 belonging to female athletes and 12 to male athletes).

#### RESULTS:

On the one hand, it can be observed that there are no major differences in the temporal distribution of the phases among participants of one or the other competitions. What we can observe is how the 2 final phases (transition and release) have a slight upward trend as the level of competition is reduced. On the other hand, although it can be seen that female athletes present a slightly higher time in the entry phase compared to male athletes, we cannot determine this finding as a significant difference. We can also observe differences between men and women regarding the discus style of release, since while most male athletes tend to throw while they are with both legs in the air, female athletes tend to do it with both feet on the ground.

#### CONCLUSION:

With the results of this study, it cannot be affirmed that there are significant differences in the temporary distribution of the phases of discus throwing among athletes participating in world championships and national level athletes. Even so, it may be interesting to study the degree of variability of the temporary distribution of the phases in the throws of the same athlete, and see if high-level athletes have less variability than the rest.

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### **EFFECTS OF A STRENUOUS ECCENTRIC KNEE EXTENSOR EXERCISE ON THREE DIMENSIONAL RUNNING BIOMECHANICS AND PHYSIOLOGIC PARAMETERS DURING AN EXHAUSTIVE ENDURANCE TEST.**

HODY, S., BURY, T., VANDENBROECK, B., LAVIEU, A., FERRÉ, A., CROISIER, J.L., SCHWARTZ, C.

UNIVERSITY OF LIEGE

#### INTRODUCTION:

The occurrence of exercise-induced muscle damage (EIMD) can affect the running pattern and endurance performance. However, the EIMD-induced changes in biomechanical and physiologic parameters remain poorly understood. The aim of this study was to examine the effects of a single isokinetic eccentric (Ecc) exercise and ensuing DOMS on running biomechanics, physiologic measures and muscle activity during an endurance exercise performed 48h later.

#### METHODS:

Ten healthy, moderately active adult men completed two treadmill running tests (at 80% Maximal aerobic speed) until exhaustion, with a week interval between both tests. Participants were submitted to a bilateral isokinetic eccentric protocol on the knee extensors 48hours before the second test. The subject's running kinematics (using a 3D motion system), heart rate, ventilation, pulmonary gas exchange and muscle activity were continuously recorded during the running tests. Delayed-Onset Muscle Soreness, plasma creatine kinase, muscle extensibility, maximal isometric force were assessed before and 48h after the ECC exercise.

#### RESULTS:

In presence of EIMD, the running time to exhaustion was shorter ( $-30 \pm 4\%$ ,  $p < 0.05$ ) while the Borg rate of perceived exertion was higher ( $p < 0.01$ ). Except for the maximal heart rate which appeared significantly higher with EIMD ( $p < 0.05$ ), the physiological data showed no significant difference between both endurance tests. In contrast, the 3D analysis and muscle activity revealed several modifications in presence of EIMD. The step frequency, the sagittal range of motion (ROM) of shoulder, and the muscular activity of the rectus femoris and the vastus lateralis increased significantly during the propulsion phase ( $p < 0,05$ ). In contrast, several other parameters decreased significantly including the stance time, the dorsiflexion of the ankle at the break phase, the maximal knee flexion during the stance phase, the ROM of pelvis during swing phase, the muscular activity of the vastus lateralis and the gastrocnemius at the braking phase ( $p < 0,05$ ).

#### CONCLUSION:

Our data suggest that the presence of knee extensors EIMD altered the running biomechanics and endurance performance without significant changes of the physiological parameters. Further investigations are required to explore whether the EIMD-induced biomechanical modifications are the result of pain perception or impaired muscle function.

### **RELATIONSHIP BETWEEN THE 5 M TIME AND THE KINEMATIC VARIABLES OF THE BACKSTROKE START**

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#### INTRODUCTION:

Starting technique is one of the most important factors for the race performance in competitive swimming. Good performances for the backstroke start are characterized by high body position for block phase and the good entry technique (arched back position) (e.g. Takeda et al., 2014). Ikeda et al. (2017) reported that the vertical velocity at take-off was significantly improved by the use of backstroke start device. Although there are several studies that focus on the kinematics while use backstroke start device (e.g. Ikeda et al., 2017), less attention has been attracted to relationships between the start performance and the kinematic variables. Therefore, the purpose of this study was to examine the relationship between the 5 m time and the kinematic variables of the back stroke start.

#### METHODS:

Seven Japanese competitive swimmers (Age =  $20.6 \pm 1.5$  years, Height =  $175.3 \pm 6.3$  cm, Weight =  $68.9 \pm 6.1$  kg, FNA point =  $746 \pm 94$ ) participated in this study. The experiment was performed at a FINA-certified indoor pool (50 m  $\times$  8 lanes, depth: 1.3-3.0 m) that had starting blocks with backstroke start device (Seiko Holdings Corporation). To evaluate the participants' start-phase performance, the time it took for the head to reach 5 m was measured while performing a backstroke at full exertion for 15 m. Trials were recorded using three synchronized video cameras (GC-LJ25B, JVCENWOOD) sampling with 120 fps and 1/1000s exposure. We analyzed the video data in 2D sagittal plane. We fed the images from the video cameras into a computer and used image analysis software (Frame-DIAS V, DKH) digitize the data and we used a 2D analysis method to calculate the coordinates of the marked points on the swimmers. We used a Butterworth digital filter on the coordinate's data. We obtained from image analysis for data smoothing. We set the digital filter cut off frequency to 13.3Hz (Winter 1979). The take-off time and 5m time were measured. During block phase, horizontal velocity, speed at take-off, angle of projection and attitude angle were calculated. Additionally, during, entry angle, attitude angle and angle of attack were computed. A correlation analysis was conducted to examine relationships between performance of start phase (0-5m time) and kinematic variables by SPSS. (PASW Statistics 25, IBM, Japan).

**RESULTS:**

A correlation analysis was conducted to examine the relationships between the 5 m time and the kinematic variables for the backstroke start. There was a significant positive correlation between the take-off time and the 5 m time ( $p < -0.05$ ) and there was a significant negative correlation between the flight distance and the 5 m time ( $p < -0.05$ ).

**CONCLUSION:**

The results of this study show that the Entry phase angle affect no the performance of start phase. Therefore, the good performance is attained with long flight distance and short take-off time.

**DYNAMIC BALANCE ABILITY AND DOWNSWING PHASE PELVIC MOVEMENT SMOOTHNESS IN GOLF PLAYERS**

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1:NCKU, 2:NTSU

**INTRODUCTION:**

Dynamic balance ability refers to an individual's ability to maintain body balance when executing an action or reacquire body balance after losing it (Winter, Patla, & Frank, 1990). In reviewing the literature on athletes' body balance and their sports performance, Hrysomallis (2011) maintained that balance ability is closely associated with sports competency. In sports biomechanical analyses, golf swings are actions that require high-precision execution, and their smoothness and movement quality can be analyzed using jerk, a kinematic parameter. Choi, Joo, Oh, and Mun (2014) reported that seasoned golf players exhibit satisfactory movement smoothness in swinging. The pelvis is a key component ensuring stable swinging. However, the effect of dynamic balance ability on downswing phase pelvic movement smoothness remains to be clarified. In the present study, a Star Excursion Balance Test (SEBT) was conducted to examine golf players' dynamic balance ability, the effect of which on downswing phase pelvic movement smoothness was also examined.

**METHODS:**

A total of 60 division 1 university golf team players were recruited (38 male, and 22 female, handicap < 5). They were scored on their dynamic balance ability through the SEBT. The top 20% and bottom 20% of participants in scores were categorized as high-balance (HBG) and low-balance groups (LBG), respectively. The two groups were analyzed for their 7-iron swinging movements; the movement smoothness of the centers of their pelvises was calculated using the method proposed by Yan, Hinrichs, Payne, & Thomas (2000).

**RESULTS:**

The HBG significantly outperformed the LBG in the x-axis (anterior-posterior) downswing phase pelvic movement smoothness, whereas the LBG significantly outperformed the HBG in the y-axis (left-right) downswing phase pelvic movement smoothness.

**CONCLUSION:**

According to Gulgin, Schulte, and Crawley (2014), hip extension and loss of posture, both of which constitute swing faults, are related to balance ability. These two faults are related to anterior and posterior pelvic movement and directly affect swing stability. The results of this study indicated that the HBG outperformed the LBG in pelvic movement smoothness in anterior and posterior directions. This was because the HBG possessed more satisfactory posture control capability than the LBG did, which enabled them to maintain movement smoothness when rotating their pelvises rapidly in the downswing phase. Previous studies have also indicated that golf players with poor dynamic balance ability are prone to swing faults in anterior and posterior directions. All the participants in this study were division 1 university golf team players; in addition to their techniques, the quality of their movement was crucially influenced by their balancing ability. Because the HBG was more satisfactory than the LBG in their pelvic movement smoothness in anterior and posterior directions, we concluded that dynamic balance ability is a key factor influencing swing stability.

**FUNCTIONAL DISSOCIATION BETWEEN VECTION AND POSTURAL CONTROL: A STUDY USING EXPANDING-CONTRACTING VISUAL STIMULATION TO THE CENTRAL AND PERIPHERAL VISUAL FIELDS**

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**INTRODUCTION:**

Optical flow from dynamic visual stimuli is known to influence postural control and to induce a synchronized postural sway in moving-room setups. Vection, the visual illusion of self-motion, also affects postural control during the presentation of dynamic visual stimuli. We previously found that the peripheral visual field mediates both efficient postural control and increased vection, but found no correlation between the two variables (Horiuchi et al., ESCoP, 2019). This suggests an advantageous function of peripheral vision for postural control in a dynamic environment and a possible functional dissociation between vection and postural control. However, the area of the peripheral visual field receiving stimulus was greater compared to that of the central visual field, which could be a confounding factor of the experiment. We therefore performed a follow-up experiment where the amount of visual information (random dots) was quantitatively equivalent in each visual field.

**METHODS:**

Twenty undergraduate students (10 male and 10 female, aged  $21.6 \pm 5.2$  years) joined this experiment. The participants were asked to perform quiet standing for 60 seconds and stare at a fixation cross on a computer screen. They were also instructed to keep pressing a hand-held button whenever they perceived vection in a trial. After each trial, they were asked to rate the strength of their vection experience. The visual stimuli consisted of approximately 25 random dots at every visual field condition (central: fixation to  $8^\circ$ , peripheral visual field:  $8^\circ$  to  $45^\circ$ , and full visual field). Stationary white random dots were presented on the screen for the first 15 seconds, after which the pattern started expanding and contracting radially for 45 seconds with 0.08 Hz frequency. Five levels of amplitude for the oscillating motion were set: 0, 25, 50, 100 and 200mm. To look for a correlation between postural control and vection, the Pearson's correlation coefficients between Center of Pressure (CoP) and vection variables were calculated at each amplitude condition.

**RESULTS:**

In each amplitude condition, the CoP variables were larger for the peripheral and full visual conditions than in the central vision condition. We found no statistically significant correlation between CoP and vection variables.

**CONCLUSION:**

The results show that the peripheral vision advantage holds, and postural sway as well as vection remain weakly correlated, even when the number of dots was decreased in the peripheral field. This expanded study reinforces our findings that the optical flow in peripheral rather than central vision affects postural sway. It further implies that there is little association between vection and postural control.

## BODY SEGMENTS' ANGULAR MOMENTUMS CORRELATION WITH IMPACT PEAK FORCES AND IMPULSE OF 3 DIFFERENT GROUND STRIKING TECHNIQUES IN MMA: A CASE STUDY

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### INTRODUCTION:

Despite interest in upper limb strikes in combat sports [1], ground striking research is still limited. This study aims to pinpoint the segments angular momentum relationships with peak impact vertical forces and the impulse of 3 different ground striking techniques.

### METHODS:

One male subject, 200 cm height, 102 kg, 38 years old, expert in martial arts, without any musculoskeletal injury, performed 3 different ground striking techniques (clenched fist direct strike, open hand palm strike, and elbow strike) with 5 trials each. 3D data were collected (MOCAP and force plates), with the subject kneeling and impacting the force plate, covered with a 1.8 cm thick polyethylene on top to protect the subject from injury. 5 global segments were used (right and left arms, right and left legs, and trunk), where total arm angular momentum was estimated as the sum of hand, lower arm, and upper arm; the total leg was the sum of the shank and thigh segments; and the total trunk was the sum of the pelvis and trunk segments. Segmental angular momentums were computed in Visual3D (C-Motion Inc., USA) relative to the full body's center of mass [2].

Each strike technique was divided into an eccentric and a concentric phase. Mean angular momentums were computed about the transverse, the anteroposterior, and the longitudinal axis. Pearson's correlation coefficients ( $\alpha=0.05$ ) were used to assess the relationships between angular momentums and vertical peak forces and vertical impulses. A similar approach for tennis serve was reported before [3].

### RESULTS:

Direct: significant correlations between mean transverse axis left arm ( $r = -0.9820$ ,  $p= 0.0029$ ) and left leg ( $r= -0.8906$ ,  $p=0.0427$ ) angular momentum, and longitudinal axis right arm ( $r=0.9033$ ,  $p=0.0356$ ) and left leg ( $r=0.8888$ ,  $p=0.0438$ ), and peak forces, were found during the eccentric phase.

Palm: correlations during the concentric phase for the anteroposterior axis mean angular momentum of the trunk and peak force ( $r= 0.8990$ ,  $p=0.0379$ ), and anteroposterior axis right arm ( $r=0.8908$ ,  $p= 0.0426$ ) and trunk ( $r=0.9088$ ,  $p=0.0326$ ) and vertical impulse, during the eccentric phase.

Elbow: correlations during the concentric phase for the mean transverse axis angular momentum of the right arm ( $r=-0.9219$ ,  $p=0.0259$ ) and trunk ( $r=-0.8956$ ,  $p=0.0399$ ) and peak force, and for the anteroposterior right leg ( $r=-0.9490$ ,  $p=0.0137$ ). The right leg also showed a significant correlation during the eccentric phase and vertical impulse ( $r=0.8856$ ,  $p=0.0456$ ).

### CONCLUSION:

Different segments showed significant correlations between angular momentums and peak vertical forces and impulses, hence different training strategies should be used to maximize performance in ground striking accordingly.

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## ARE MOUTHGUARD USE RESPONDERS CONSISTENT IN DIFFERENT POWER TESTS AMONG BASKETBALL PLAYERS?

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### INTRODUCTION:

Different types of mouthguards (MG) have been used in basketball to protect the maxillofacial structure. Besides, recent researches have investigated its neuromuscular advantages on strength and muscular power performance (Allen et al., 2018). The reason of these benefits may be associated to a phenomenon called concurrent activation potentiation (CAP), promoted by the remote voluntary contraction (RVC) of the mandible muscles (Ebben et al., 2008; Buscà et al., 2016). It has been reported that the use of these devices facilitate a better temporomandibular repositioning and a more powerful occlusion, which may magnify the effects of the CAP (Arima et al., 2013). The aim of the present study was to investigate whether the ergogenic effects promoted by the use of a custom-made MG are consistent in different power tests among basketball players.

### METHODS:

Twelve professional basketball players ( $21.07 \pm 4.11$  years, height:  $1.98 \pm 7.31$  m, weight:  $91.05 \pm 10.92$  kg) involved in a Spanish "ACB-Liga Endesa" club participated voluntarily in the study. A randomized within-subjects design was used to determine the ergogenic effects of jaw clenching wearing a custom-made MG on muscular performance. Additionally, an individual responder's analysis using the results' difference between MG and NO-MG condition was conducted to examine the consistency of the effects on vertical jumps (CMVJ and CMVJa) and agility test (T-Test).

### RESULTS:

In the case of jumps, the 50% of the subjects improved in one or both jumps because of the MG use, while only the 8.3% responded negatively in one set of each test. The remaining 41.6% were considered as non-responders, as long as there was not observed any difference ( $\pm 5\%$ ) between conditions. Regarding the agility test, the 33.3% of the subjects responded positively because of the use of MG, while the 66.7% were considered as non-responders. None of the participants responded negatively in the agility test. Considering the overall response, the 58.3% were considered as positively responders in, at least, one of the three tests, without any negative impact in the other tests. However, only the 16.7% responded positively in one of the vertical jumps and in the agility test.

### CONCLUSION:

The results are in line with Arent et al. (2010), who demonstrated ergogenic advantages as the result of the MG use in, at least, one of the vertical jumps or in the agility test, without any negative effect in the other ones. However, this study did not find any correlation between the mentioned tests. Although the lack of consistency between the tests, the positive effects found, may encourage athletes to wear custom-made bite-aligning MG, specially whose sports require anaerobic efforts and also mouth protection, as in the case of basketball.

## UNILATERAL NON-ELECTRIC ASSISTIVE WALKING DEVICE HELPS NEUROLOGICAL AND ORTHOPAEDIC PATIENTS TO IMPROVE GAIT PATTERNS

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### INTRODUCTION:

Pathological gait patterns are common in older adults, as well as in neurological and orthopaedic patients which put them at risk of falling, restricting autonomy and social participation. Novel assistive walking devices are designed to actively support physiological gait patterns by means of motor guidance and mechanical support of the lower limbs. This study aimed at investigating a non-electric assistive walking device powered by a cam spring mechanism (aLQ, imasen) in neurological and orthopaedic patients.

### METHODS:

A three-dimensional instrumented gait analysis was conducted on a treadmill (quasar, hp cosmos) using spatiotemporal, kinetic and kinematic data obtained from synchronized motion capturing (Miquis M3, qualisys), surface EMG (sEMG; Ultium, Noraxon) and pressure distribution measurements (FMD-T, zebris). Participants with impaired walking were tested in a 2x2 within-subjects design (with/without aLQ device; at preferred/fast speed) and assigned either to the orthopaedic (n=20) or neurological group (n=20) with regard to their medical condition.

### RESULTS:

Results indicate an increase in stride length for orthopaedic ( $t = 3.51^{**}$ ,  $p = .001$ ) and neurologic patients ( $t = 10.26$ ,  $p = .07$ ) and both groups demonstrate a significant decrease in cadence (neurologic  $t = -0.40^{*}$ ,  $p = .03$ ; orthopaedic  $t = -0.40^{**}$ ,  $p = .004$ ) when using aLQ compared to baseline. Hip joint angle shows a significant increase in sagittal maximum flexion in both groups (neurological  $t = -4.05^{**}$ ,  $p < .001$ ; orthopaedic  $t = -4.00^{**}$ ,  $p < .001$ ), whereas joint knee angles seem not affected. Overall gait variability depicted by the gait profile score significantly improved in the neurologic group ( $t = 0.27^{**}$ ,  $p < .001$ ). Muscle activity adapts to aLQ during initial swing phase but did not differ significantly from baseline.

### CONCLUSION:

In our study, participants seem to benefit from the assistive walking device regarding gait and movement patterns. We conclude that the tested device may help to improve patients' functional health status and quality of life. Activities of daily living (ADLs) that involve extensive hip flexion like stairs or curb climbing are promising application situations. With regard to product development, we propose to implement an invertible cam spring that provides an additional resistance training option. Further studies should focus on the facilitation of ADLs using assistive walking devices and verifying long-term benefits in patients' autonomy and social participation.

## VALIDITY OF ELECTRO-GONIOMETERS AS A METHOD OF MEASURING CONTINUOUS RELATIVE PHASE DURING CYCLING.

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### INTRODUCTION:

It has been established that significant differences exist between laboratory-based and field-based performances in cycling (1) and more ecologically valid scenarios for testing have been advocated (2). In order to do this, the validity of mobile measurement systems must first be established by comparing against criterion measures synchronously obtained using previously validated equipment. The aim of this study was to assess the validity of electro-goniometers as a method of recording continuous relative phase data at two joint couplings during cycling tasks at a range of cadences.

### METHODS:

Seven participants (4 male, 3 female age:  $29 \pm 7$ y, height:  $1.76 \pm 0.10$ m mass:  $71.97 \pm 11.57$ kg) performed exercise bouts of 30s at four prescribed cadences (60, 80, 100, 120 rev.min<sup>-1</sup>) on a stationary ergometer (Wattbike, UK). Measures were synchronously recorded by bi-axial electro-goniometers (Biometrics, UK) and a 12-camera motion capture system (Qualisys, Sweden) with both systems sampling at 500Hz. Sagittal plane joint angle and joint angular velocity was recorded at the hip, knee and ankle and analysed for 10 complete pedal revolutions per participant per condition. Data was interpolated to 100 time points and used to calculate Mean Continuous Relative Phase (CRP) per pedal revolution at two intra-limb couplings: (i) knee flexion/extension–ankle plantarflexion/dorsiflexion (KA) and (ii) hip flexion/extension–knee flexion/extension (HK). Repeated measures difference testing was used to check for significant differences between measurement systems followed by calculations of intraclass correlation coefficient (ICC) using a two-way mixed model. Statistical analysis was conducted using SPSS (IBM, USA) with an alpha level of 0.05.

### RESULTS:

At the KA coupling, significant differences in mean CRP were found between measurement systems at 120 rev.min<sup>-1</sup> ( $p=0.006$ ). At the HK coupling, significant differences in mean CRP were found between measurement systems at 80 rev.min<sup>-1</sup> ( $p=0.043$ ) and 100 rev.min<sup>-1</sup> ( $p=0.028$ ). ICC values for all comparisons were below 0.5 suggesting poor levels of agreement between systems (3). Two exceptions were KA at 60 rev.min<sup>-1</sup> (ICC=0.749) and 80 rev.min<sup>-1</sup> (ICC=0.664) which show moderate levels of agreement. Initial interpretation suggests the lack of even surfaces on which to mount electro-goniometers (4) may have contributed to a discrepancy between joint axis orientation and that of the measurement device but further analysis is recommended to confirm this.

### CONCLUSION:

Significant differences in mean CRP per pedal revolution and poor levels of agreement between systems suggests that electro-goniometers are not a suitable alternative to motion capture systems when attempting to record CRP during cycling.

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## EFFECT OF ABSTRACT EXPRESSION ON THE ACCURACY OF JOINT ANGLE MATCHING

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### Introduction

Several reports have investigated the accuracy of joint angle reproduction. For example, the effect of age, fatigue, and orthopedic disease on the reproducibility of joint angles were reported. In those reports, the aimed angle which subjects reproduce were specified with numerical values such as “45degrees extension”, “90degrees flexion”. In the fields of physical education, however, teachers or coaches often add the abstract expression such as “a little extension than 45degrees flexion”. The purpose of this study was to clarify the influence of abstract expression on the joint angle reproducibility.

#### Methods

Fourteen subjects were participated in the experiment. Experiment was conducted in accordance with the Declaration of Helsinki. In the reproduction task, subjects were sit on the stable chair. Subjects were instructed to reproduce their elbow joint angle at a sagittal plane which specified by experimenter. The target angles were set at 6 conditions, i.e. 45degree flexion, 90degree extension, a little flexion than 45degree flexion (F-45), a little extension than 45degree flexion(E-45), a little flexion than 90degree flexion (F-90), a little extension than 90degree flexion (E-45). Five trials were conducted in each angle, and all trials were randomized. Additionally, subjects were asked how degree they imaged in each condition.

The constant errors from criterion angle condition (45deg, 90deg) to actual angle in F-45, E-45, F-90, E-90 were calculated. For the statistical analysis, Two-way ANOVA by means of angle factor and direction factor was conducted. Post hoc comparison was made using Bonferroni; the threshold for statistical significance was set at  $p < 0.05$ .

#### Results

Significant main effects were observed in direction factor and angle factor, respectively. In direction factor, flexion was larger than extension ( $p < 0.05$ ). In angle factor, 45degree was larger than 90degrees ( $p < 0.05$ ). The interaction was not observed. The imaged angles were about 5-10degrees from criterion angles. There was not significant difference among each condition.

#### Discussion

The imaged angles from criterion angles were not different among each condition. In spite of that, significant difference was observed between extension and flexion. This phenomenon was considered due to differences of information of proprioception. In this study, subject reproduce their joint angle in sagittal plane. When they extend elbow joint, biceps brachii contracted eccentric. On the other hand, when they flex elbow joint, triceps brachii was slacken. The proprioceptive information was perceived as a result of muscle spindle afferent differences between agonist and antagonist muscles. Furthermore, the error of 45degrees was larger than 90degrees. In the oriented angle was 90degrees, biceps brachii and triceps brachii were in co-contracted state than the oriented angle was 45degrees. These differences were affected to perceived proprioceptive information in each condition.

## DYNAMIC BALANCING SKILL IN THE BALANCE SPORT “SLACKLINING”: A COMPARISON OF NOVICE AND EXPERT

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#### INTRODUCTION:

This study aimed to shed light on the skill of “slacklining” and its acquisition. Slacklining is a balance sport that requires players to maintain their body balance dynamically and flexibly. Researchers have investigated the effect of slackline training on balance ability [1]. However, the skill of slacklining remains unknown to many.

In slacklining practise instructors teach learners their knowledge of ways on how to maintain balance on a swinging flat belt (slackline), such as moving both hands in parallel, based on their own experience. We hypothesised that single-leg standing on a slackline is a fundamental skill of slacklining, and that bimanual coordination in the horizontal direction might contribute to whole-body dynamic balancing on a slackline [2].

#### METHODS:

Novice (N=5, 3 women, mean  $\pm$  SD, 22.6  $\pm$  3.4 years old) and expert (N=5, 3 women, mean  $\pm$  SD, 28.4  $\pm$  11.1 years old, including the Japanese women’s slackline champion) players participated in our experiment. Participants were required to perform a single-leg standing task on a slackline. To collect motion data of participants while slacklining, we used a 3D motion capture system and obtained time series data on the wrist position of both hands. We also evaluated the dynamic stability of bimanual coordination using nonlinear time series analysis (cross-recurrence quantification analysis [3]).

#### RESULTS:

The results of the comparison of novice and expert players’ bimanual coordination showed that dynamic stability (e.g., percentage determinism and the average of the diagonal length [3]) were higher in the expert group than in the novice group.

#### CONCLUSION:

The results showed the possibility that bimanual coordination during single-leg standing on a slackline is an important parameter for acquiring the fundamental skill of slacklining. Bimanual coordination can be an index of skill acquisition in slacklining. This pilot study needs to be clarified through further investigation that should collect more data and analyse the relationship between bimanual coordination and whole-body balancing. Knowledge of slacklining skills would lead to not only understanding the skill of a balance sport slacklining but also the development of a safe and efficient balance training in whole-body dynamic balancing.

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## LANDING BIOMECHANICS FOLLOWING ECCENTRIC EXERCISE-INDUCED MUSCLE DAMAGE

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#### INTRODUCTION:

The execution of jumps is an integral component in sports activities and multiple jumps are typically performed in sports such as soccer, basketball and handball. The accompanying landing movements are associated with a considerable risk for injury to the musculoskeletal structures of the lower body, particularly those of the knee joint. Moreover, the increase in physical demands due to short between-match

recovery periods and the large number of intense, eccentric muscle actions during typical movement patterns seen in gameplay are known to cause exercise-induced muscle damage (EIMD) of varying degrees. Athletes often practice or compete in games on consecutive days regardless of the presence of residual muscle damage and soreness. EIMD has not been explored in the literature as a potential risk factor for lower limb injuries during landing activities. Therefore, the purpose of this study was to examine the effects of EIMD on landing biomechanics during the execution of a drop-jump task.

#### METHODS:

15 physically active men ( $21 \pm 2$  years;  $181 \pm 59$ cm;  $79 \pm 8.6$ kg) performed an EIMD protocol consisting of 5×15 isokinetic eccentric maximal knee extensor voluntary actions of both lower limbs at 60°/s. Muscle damage indicators included isometric peak torque, delayed onset of muscle soreness (DOMS) and serum creatine kinase activity. Subjects performed a drop vertical jump task from 30cm before and 48h post-exercise. Kinematic data were acquired using a 10-camera 3-D analysis system (Vicon T-series), operating at 200 Hz. Two force platforms (Bertec 4060-10, OH) embedded in the laboratory floor captured GRFs at 1000 Hz synchronized with the kinematic data. ANOVA with repeated measures (two limbs x two measurements) were used for statistical analysis of EIMD indicators and kinematic and kinetic parameters of interest. The significance level was set at  $P < 0.05$ .

#### RESULTS:

Eccentric exercise induced significant development of DOMS, decline of isometric peak torque and increase in creatine kinase activity 48h post-exercise ( $p < 0.05$ ). Compared to pre-exercise values, kinematic and kinetic analysis revealed a more flexed knee and hip angle, a decreased peak knee moment and vertical GRF during the absorption phase of the drop jump-task ( $p < 0.05$ ). No significant differences were found between the two lower limbs pre- and post-exercise for the EIMD indices as well as for the biomechanical parameters examined during landing ( $p > 0.05$ ).

#### CONCLUSION:

The increased flexion observed at the knee and hip joints during the absorption phase of the drop-jump task while being in a muscle damaged state reduced the effective mass of the body and thereby decreased the peak GRF during the impact phase. This mitigates the loads applied to the joint structures during the employed landing task and reduces the risk of acute injury. However, the increased time of absorption that accompanies increased joint flexion during landing may not be conducive to the rapid movements required during many sports activities.

### EVALUATION OF SMALL AND DEEP MUSCLE ACTIVITIES DURING HANDWRITING USING 18F-FDG POSITRON EMISSION TOMOGRAPHY

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#### INTRODUCTION:

Human hand is remarkably dexterous. Handwriting is one of the human specific ability, which requires coordination of a myriad of small and deep muscles. Hence, understanding how these muscles are coordinated during handwriting is important in human motor control and may help to develop rehabilitation methods or myoelectric hand prosthesis. Surface electromyography (EMG) is a popular tool to evaluate muscle activity. However, surface EMG is inappropriate for evaluating small and deep muscle activities. Positron Emission Tomography (PET) allows to assess muscle activity including small and deep muscles without restriction of body movement by using glucose tracer; Fluoro-deoxy-glucose (FDG). The purpose of this study was to examine hand and forearm muscle activities during handwriting (complex movement) and tapping (simple movement) using FDG-PET and surface EMG.

#### METHODS:

Ten healthy, right-handed male subjects participated in this study. Subjects were randomly divided into either handwriting (HW: 6 males) or tapping (TAP: 4 males) groups. In the HW task, the participants continuously traced the number from 0 to 9. In the TAP task, they tapped a key with index finger at about 180 beat per minutes. In both tasks, one session consists of 150 seconds, followed by 30 seconds rest. The participants repeated the session 10 times. sEMG was measured from seven hand and forearm muscles. Integral electromyogram (iEMG) and mean power frequency (MPF) were calculated for further analysis. PET/MRI scan was performed with a Biograph mMRI (Siemens AG, Erlangen, Germany) after the completion of each task. We evaluated muscle activity with standard uptake ratio of FDG. Regions of interest were specified by tracing the outline of each muscle on the MRI-T2 image. We identified muscle activities from 6 hand and 12 forearm muscles with FDG-PET.

#### RESULTS:

MPF gradually decreased in the first dorsal interosseous (FDI) muscle during the HW task ( $P < 0.05$ ). We observed no changes in iEMG of all muscles during HW and TAP tasks. These results indicate that muscle fatigue was observed in the FDI muscle during HW task. Glucose uptake increased in most hand and forearm muscles including deep forearm muscles during the HW task. In contrast, during the TAP task, glucose uptake increased only in extensor digitorum muscle. In the FDI muscle, iEMG tended to be correlated with glucose uptake during the HW task ( $P = 0.055$ ). However, no correlations were observed between iEMG and glucose uptake in the surface forearm muscles.

#### CONCLUSION:

The present results clearly suggest that handwriting required muscle activity including deep, small forearm muscles. The absence of correlation between sEMG and PET data in the surface forearm muscles support the notion that sEMG may be affected by cross-talk from neighboring muscles. FDG-PET is a valuable tool to identify forearm muscle activities that require fine motor control.

### THE ISOMETRIC LENGTH-TENSION RELATIONSHIP IS NOT DIFFERENTIALLY AFFECTED BY REGIONAL QUADRICEPS MUSCLE ARCHITECTURE

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#### INTRODUCTION:

Muscle mass and architecture [muscle thickness (MT), pennation angle (PA), fascicle length (FL)] assessments have been extensively used to model in-vivo isometric and concentric knee-extension performance (e.g., 1,2). However, the relationship between regional (proximal, middle, distal) muscle architectural variations and in-vivo isometric torque at short, medium, and long muscle-tendon-unit lengths is unknown.

#### METHODS:

Regional quadriceps MT, PA, and FL of 24 resistance-trained males (48 limbs) were assessed via snap-shot and extended field-of-view ultrasonography. Participants performed maximal voluntary isometric torque (MVIT) and rate of torque development assessments at 40°, 70°, and 100° of knee flexion (full extension=0°). Measures were recorded over three visits. Architectural variables were averaged across all sessions to reduce errors arising from sonographer or participant variability. The greatest MVIT across the three sessions was utilized to reduce errors from submaximal voluntary activation. Linear regression models predicting angle-specific torque from regional muscle architecture provided adjusted simple and multiple correlations (adjR), and were interpreted as trivial<0.10, small≥0.10, moderate≥0.30, large≥0.50, very large≥0.70, and extremely large≥0.90. Correlations were further assessed for magnitude using bootstrapped compatibility limits (3).

#### RESULTS:

MT of all muscles and regions had sufficient intersession reliability (ICC>0.60 (3)), however, PA and FL could only be reliably assessed at each region in the vastus lateralis. MVIT was also highly reliable, whereas rate of torque development measures did not surpass the reliability threshold required for inclusion in correlational models. Middle vastus lateralis MT and MVIT at 100° (adjR=0.64) was the largest single correlation, with distal vastus lateralis MT having the greatest mean correlations regardless of angle (adjR=0.61±0.05). Lateral distal architecture had larger ( $\Delta$ adjR=0.01-0.43) single and multiple correlations with MVIT than the lateral proximal (adjR=0.15-0.69 vs -0.08-0.65), regardless of joint angle. Conversely, middle anterior MT had greater ( $\Delta$ adjR=0.08-0.38) single and multiple correlations than proximal MT (adjR=0.09-0.49 vs -0.21-0.14), regardless of joint angle.

#### CONCLUSION:

Our data demonstrate that the relative contribution of regional quadriceps architecture does not change through the in-vivo length-tension relationship. However, other than vastus lateralis FL, middle and distal architecture were the strongest predictors of MVIT. Researchers can utilize these results to streamline evaluations of knee extensor performance and anatomy. Future research may utilize nerve stimulation, electromyography, and isokinetic contractions at different velocities to further elucidate potential relationships between muscle form and angle-specific function.

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## COACHING

### EXAMINATION OF LOAD COMPONENTS AMONG THE YOUNG SOCCER PLAYERS

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#### Introduction

The IMA parameters of Mechanical Workload mean the indicators of agility during young soccer players' training sessions. Players who are able to do rapid onsets, sudden stops and changes in direction in a small area of the football pitch can become really efficient.

#### Methods

U15, U16, U17, U19 junior soccer teams of Illés Academy Szombathely, Hungary; N=71. We measured the parameters below: Height, Weight, YoYo IRTL1, 30M, FMS, Standing Long Jump (SLJ). Training reports measured with Catapult Sports including the components of IMA Maximum Intensity Mechanical Workload: Total Player Load (TPL), Acceleration High (AH), Deceleration High (DH), CoD Right, CoD Left, Jump Count Band, Explosive Efforts. We studied the variables of the average weekly indicators of a 6-week training cycle. The data have been processed with the IBM SPSS Statistics25 program ( $p<0.05$ ).

#### Results

The players of Illés Academy do well at the motoric tests: YoYo IRTL1 (M=2155, SD=311), 30M (M=4.34, SD=0.26), SLJ (M=2.28, SD=0.18) they show dynamic improvement at different age groups. Lower performance is experienced at U17 in the FMS analysis. In the case of Standing Long Jump and Weight (R=0.62), Height (R=0.65), 30M (R=0.69) moderate correlation can be experienced. Between the Explosive Efforts and the Mechanical parameters below strong and significant correlation can be experienced (TPL 0.61, AH 0.83, DH 0.79, CoDL 0.87, CoDR 0.83). The measured variables are statistically varied at different age groups except for TPL, AH and CoD Left on the basis of ANOVA test. The difference between U15 and U16 parameters is the most noticeable. In the case of U19 the slight decrease of Maximum Intensity parameters is experienced.

#### Discussion

During young soccer players' training sessions the frequency of High Intensity Movements (Acceleration, Deceleration, CoD Right, CoD Left, Jump Count Band, Explosive Efforts) should be increased for the sake of higher efficiency.

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### CHANGES IN PHYSICAL EDUCATION TEACHERS' SITUATION AWARENESS BY USING VR VIDEOS

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#### INTRODUCTION:



In Japan, increasing efforts to understand and improve the competence of teachers have recently been made through the "On-going Method" (developed by Ikuta in 1998) and the "Video Annotation System" (developed by Nishihara in 2017), both of which are intended for training teachers. Simultaneously, in Japanese manufacturing industries, which are now facing the problem of successor shortage, the inheritance of craftsmanship and the development of human resources are accomplished with the use of virtual reality (VR) videos. Against this background, we have studied and clarified the characteristics of situation awareness in classroom teaching by skilled and novice teachers with the use of VR videos. In addition, we have also clarified the kind of awareness and learning that could occur in the minds of novice teachers when they observe the VR view videos of the skilled teachers' situation awareness.

#### METHODS:

Using a 360-degree omni-directional camera, we recorded a video of a junior high school physical education (basketball) lesson conducted by a middle-ranked teacher with 12 years of teaching experience. By showing that VR video to skilled and novice teachers, we also recorded VR view videos of the particular points that individual teachers or groups were paying attention to in the video, and their comments about why they were watching them.

#### RESULTS:

The recorded numbers and percentages of the comments by skilled and novice teachers revealed that there were more comments by skilled than by novice teachers about the following factors: "Flow of lessons" (novice teachers: 7%; skilled teachers: 12%) and "Overall plan" (novice teachers: 6%; skilled teachers: 13%). Meanwhile, novice teachers paid more attention to "Athletic skill" than did skilled teachers (novice teachers: 29%; skilled teachers: 19%). There was no difference between the two groups in terms of "Motivation," "Learning environment," "Praise," and "Teachers guidance." There were a greater number of comments by skilled than by novice teachers. After we showed the skilled teachers' VR view videos to the novice teachers, the percentage of novice teachers who paid attention to "Overall plan" slightly increased from 2% to 6%. The differences in terms of comments between the skilled and novice teachers after watching the same video are as follows. The skilled teachers' comments considered both the motivation of the students and the overall plan of the school: "The low motivation of this student for learning is attributable to the difficult assignment, and this assignment is also difficult for several other children. In the overall plan, basic training seems to be insufficient." On the other hand, novice teachers' comments were more about a surface phenomenon: "This student is unmotivated and not actively working."

#### CONCLUSION:

The above results reveal that many skilled teachers analyze what happens in front of their eyes by considering the flow of lessons and the overall plan, not by simply deeming it as some sort of phenomenon. In other words, skilled teachers try to analyze the various factors that bring about what they see from a comprehensive viewpoint.

### THE RELATIONSHIP BETWEEN REBOUNDING SKILLS AND THE EXPERIENCE OF A FAVORITE SPORT EVENT, THE PAST EXPERIENCE OF BASKETBALL, GENDER AND STANDING HEIGHT

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1> FUKUOKA UNIVERSITY, 2> HIROSHIMA DRAGONFIRES

#### INTRODUCTION:

Even in basketball PE classes in the faculty of physical education course, to measure fundamental basketball skills, skill tests are often utilized. However, each student with a PE major has a favorite sport event other than basketball and this experience can be thought of as influencing the results of the skills test. At the same time, basketball experience, such as mini-basketball, gender, standing height and other factors are also assumed to impact it. If these are involved as well as the learning effect in the class, students who take the class should be graded with consideration of them. Thus, this study is to investigate these relationships between basketball skills and them. In particular, rebounding skills are focused on. However, as those whose favorite sport event is the same train with the same practice every day, a mixed linear model was used in this study to consider the dependency of it.

#### METHODS:

The subjects were 244 university students who took a basketball class in the sport-related faculty of F-university in Japan. They were asked to perform the rebounding skills test four times. In the test, they tossed the ball to the backboard from the front of the board, caught the rebounded ball in the air and then tossed the ball to the board again. They repeated this action as quick as possible in 30 seconds. The times this was performed was counted. At the same time, the sport club they belong to, gender, standing height, and basketball experience in elementary school, junior high school and high school were surveyed. The sport clubs were categorized into "Basketball," "Ball games," "Sports other than ball games," "No club" and "Major other than PE." As the repetition by individual, sport club and category of sport clubs has a nested structure, a mixed linear model with them as a random effect was used to investigate the relationship between them.

#### RESULTS:

As a result of deviance analysis between the model including only random effects (deviance = 5647.3) and the model adding gender, standing height and the past experience of basketball as a fixed effect (deviance = 5514.7), a significant good-of-fit (chi-squared = 132.58, df = 5,  $p < 0.001$ ) was found. In the random effect, intra-individual variance (7.12), sport-club variance (2.58) and variance of category of sport clubs (0.95) were significant at the level of 0.1%, indicating that rebounding skills are impacted by these three factors. Next, when glancing at the fixed effect, a partial regression coefficient of men was 3.35, that of standing height was 0.18, and that of the basketball experience in elementary school was 0.41, that of junior high school was 0.52, and that of high school was 1.05. Although the basketball experience in high school was also significant at the level of 5%, an inevitable impact was also found in that of men and that of standing height.

#### CONCLUSION:

Fundamental basketball rebounding skills were influenced by the target's present favorite sport events, gender and standing height.

### A STUDY OF TRENDS IN THE HISTORICAL DEVELOPMENT OF ELEMENTS AND TECHNIQUES ON THE UNEVEN BARS OF WOMEN'S ARTISTIC GYMNASTICS

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#### INTRODUCTION:

Artistic gymnastics has a huge number of elements. Coaches must decide which element to teach and in what order in their daily training. In order to plan training for the future, it is necessary to read the trends and development trends of each apparatus and identify technique that are worth passing on (Sano / Watanabe 2019).

Therefore, in this study, by organizing the trends in the historical development of elements and techniques related to uneven bars (UB) of women's artistic gymnastics, we clarified the factors associated with the development of UB elements, and to find knowledge for developing a systematic theory of gymnastics elements.

#### METHODS:

In this study, we collected and organized historical data on UB. The types of materials were rules (Code of Points, Apparatus norm, Competition rule etc), video materials, and research materials.

#### RESULTS:

In the late 19th century, UB in women's gymnastics began with men's parallel bars, and the distance between both bars was only 80cm. The cross-section of the bar was oval rather than round, and many of the elements were the same as men's parallel bars. Gradually, the apparatus norm was improved, and in 1964, the height of the high bar was 230cm, the height of the low bar was 150cm, the cross-section of the bar was 51x41mm, and the distance between both bars was 430-480cm. Today in 2020, the height of the high bar is 250cm, the height of the low bar is 170cm, the cross-section of the bar is 40mm circle, and the distance between both bars is 130-180cm. To date, a huge number of elements have been developed and performed by athletes. Some of those elements had disappeared to date.

#### CONCLUSION:

Analysis of the history of technological development has revealed the following.

- 1) The announcement of the "Giant circle bwd. in regular grip on high bar" by the former Soviet SHAPOSHNIKOVA N. in 1977 had deep impact on technological development.
- 2) With the giant circle announcement, the distance between both bars has been expanded, and it had a significant impact on the development of the current dynamic swing, the technique of flight element, and the technique of moving to another bar.
- 3) Due to the tendency of scoring rules to become objective, it became clear that there was a tendency to continuously perform difficult element.

By this research, Effective knowledge on the technological development history of UB of women's artistic gymnastics was obtained.

### YOUTH OLYMPIC GAMES – SUSTAINABLE LONG-TERM SUCCESS IN TRACK AND FIELD ATHLETES ?

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#### INTRODUCTION:

Since Singapore 2010 every four years youth athletes (age under 18 yrs (u18)) compete in various sports within the Youth Olympic Games (YOG). In recent years there is an increasing scientific interest regarding the evolution of youth to senior performance in athletes. In elite senior track and field athletes (T&F) athletic peak performance (APP) is reached in the mid-twenties (sprinters earlier than jumpers, throwers and endurance runners). The developmental trajectory of APP is nonlinear and highly variable due to the individual biological adaptation. Aim is to investigate the performance increment and competitive success in selected YOG T&F medallists from elite youth to junior/senior athletes as well as to evaluate their development.

#### METHODS:

The data were extracted from a renowned database ([www.worldathletics.org](http://www.worldathletics.org)) through 12/2019. Competition results of 48 female and 48 male medallists (1st-3rd place) of five T&F discipline blocks (sprint (SP: 100 m, 400 m), middle (MD: 800/1000 m) and long distance (LD: >3000 m) runs, jumps (JP: high jump, triple jump), throws (TR: discus, javelin) at YOG (2010, 2014) as well as their performance profiles of legally achieved outdoor season bests were empirically analysed. Comparisons of selected age groups, of athletes careers (AC) and further champs were made.

#### RESULTS:

The YOG medallists achieved performances from 81.5±4.7% (TR) to 95.1±1.3% (SP) of world's u18 best. Meanwhile personal bests (PB) range from 77.8±6.1% relative to actual world record (WR) at APP of 20.1±1.9 yrs in TR to 92.8±2.6% at APP of 19.4±2.0 yrs in SP. Unfortunately the further trend in performance development is often in decline. Normally annual performance gain depends on age: u18 ~4% and more, u20 ~2%, u23 ~1% and seniors (SEN) ~0-1%. YOG medallists often reach their PB within 2.6±2.2yrs after medal success. The attrition rate (%) until 2017 was 25 % (13 female & 11 male athletes) per discipline block: 3 % (SP, MD), 4-5 % (JP, TR), and 9 % (LD). Of the remaining 75%, only 4 athletes have so far achieved success (medals at SEN champs) as an adult athlete.

#### CONCLUSION:

Due to an accumulation of adolescent competitions and shifting of APP to younger age there is a need of deeper understanding and knowledge of individual physiological responses and cellular adaptation mechanism in adolescents (possibilities & limits) – time for adaptation and perfection in terms of movement technique: SP < MD < JP < TR < LD. This should lead to a revision of existing basic conditions, methodological training prescriptions and youth competitions. Simply copying the training load from senior elite athletes to their youth counterparts in the early stage of AC often leads to a short and rapid success but for a long-term, sustainable rate of performance increase, it is mostly senseless. In conclusion, excelling, without enough attention on the biological domain, at youth level in competitive T&F is not a prerequisite for a senior success.

### THE RELATIONSHIP BETWEEN PEAK HEIGHT VELOCITY AGE AND PERFORMANCE TESTS IN YOUTH ATHLETICS PLAYERS.

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#### INTRODUCTION:

Performance tests helped predict competition performance and plan training programs. Differences in maturity affected physical characteristics during adolescence. In particular, for youth athletes who were going through a growth spurt, individual maturity differences must be considered to provide optimal training programs (1). This study aimed at investigating the relationship between peak height velocity age (PHVA) and performance tests.

#### METHODS:

126 junior high school boys (Height: 164.8±7.5 cm, Weight: 52.3±10.3 kg, Age: 14.1±0.9 years) participated in this study. Height, sitting height, weight were measured as physical parameters. They performed 8 events performance tests (50m sprint, standing long jump, 5 steps jump, single-leg 3 steps jump, cross hopping, medicine ball throw, and grip strength). And they performed Wingate test. The applied resistance was 7.5% of body weight, and the duration was 10 seconds. PHVA was calculated using the formula of Mirwald et al. (2). Years

from PHV predicted from anthropometric data was used as a maturity indicator. The participants were divided into pre-PHVA group (n=43) and post-PHVA group (n=83).

**RESULTS:**

The mean value of PHVA was 13.7±0.5 years. There was a significant correlation between the results of all performance tests and chronological age, PHVA. Also, the correlation coefficients were higher in PHVA than chronological age in most events. In the pre-PHV group, although there was a significant correlation between the performance of the medicine ball throw, grip strength and pedaling power, and PHVA, but not 50m sprint, standing long jump, standing 5 steps jump, and single-leg 3 steps jump. In the post-PHV group, there was a significant correlation between PHVA and events except for single leg 3 steps jump.

**CONCLUSION:**

Our findings show that the different results were obtained depending on the group. In the pre-PHV group, it is suggested that the stagnation of performance is not accompanied by technical factors and development of muscle functions such as skill for exerting muscle strength and power. There are some points that can be understood by verifying with prePHV and postPHV. Growth development needs to be considered. These results suggest that it was able to obtain training suggestions and coaching knowledge for youth athletics player.

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## DISABILITIES

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### **A MULTICOMPONENT EXERCISE INTERVENTION TO IMPROVE PHYSICAL FUNCTIONING, COGNITION AND PSYCHOSOCIAL WELL-BEING IN ELDERLY NURSING HOME RESIDENTS WITH DEMENTIA: AN OBSERVATIONAL FEASIBILITY STUDY**

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**INTRODUCTION:**

Dementia is associated with memory loss and in the long term often leads to loss of independence, which reduces the quality of life and increases mortality [1]. Dementia patients show increasing gait insecurity [2], especially in everyday situations that require simultaneous processing of external information while performing cognitive motor tasks. Specific exercise programs can help to maintain aspects of cognitive-motor performance [3]. Exercise also appears to improve the performance of activities of daily living. However, there is neither sufficient evidence for pharmacological nor non-pharmacological therapies. Furthermore, many studies exclude persons with high cognitive function losses. The aim of the present study is to evaluate the feasibility of a multicomponent exercise program for people with moderate to severe dementia.

**METHODS:**

Fifteen nursing home residents with moderate to severe dementia received 16 weeks of multicomponent training (warmup, coordination, cognition, walking, strength and relaxation) for one hour once a week. Participation, the number of exercises performed, and the type of instruction were documented by means of standardized observation protocols. For the qualitative analysis, a questionnaire with open questions was filled out by the nursing staff after the end of the intervention.

**RESULTS:**

On average 10.5 persons attended the intervention. Of these attendees 46% actively participated. Of all five components, the gait exercise was the component where most people were active (64%). The lowest active participation was observed during the strength exercises (33%).

**CONCLUSION:**

This study confirms that specific training for people with severe dementia is feasible. To ensure sufficient supervision, the group size should not exceed 15 people. In addition to the appropriately qualified instructor, a supervising nurse should also be present. In order to enable active participation for as many persons as possible, gait exercises in particular should be implemented. This component could also counteract the dementia associated increasing gait insecurity [2].

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### **HIP ADDUCTOR AND ABDUCTOR MUSCLE STRENGTH IN COLLEGIATE FOOTBALL ATHLETES AND RELATIONSHIP WITH GROIN INJURIES**

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**INTRODUCTION:**

Groin injuries frequently occur in football players, causing the loss of time from training and competition. Hip abductor and adductor muscles are important for stability of the pelvis, especially one-leg standing situations, like during jumping, landing, cutting, and kicking the ball. Hip muscle weakness and imbalance may decrease hip and pelvis stability and cause groin injuries. The purpose of this study was to investigate the relationship between pre-season hip muscle strength and groin injuries.

**METHODS:**

Seventy-six male collegiate football players from a team participated in this study. During pre-season, hip adductor and abductor muscle strength were measured using a hand-held dynamometer (Commander Echo Muscle Tester, Nihon Medix, JAPAN). During measurement, the subjects lay on their back with their leg in a neutral position. A hand-held dynamometer was held in the medial epicondyle of the femur

in the case of hip adductor muscle strength measurement and lateral epicondyle in the case of hip abductor measurement by a strap. The subjects performed hip abduction and adduction with maximum isometric muscle contractions twice each. Maximum values were used for analysis. Injury surveillance was performed by team physicians during the season. Based on the results of injury surveillance, subjects who developed groin pain were placed in the groin pain group, and others were placed in the control group. The difference in hip muscle strength between the dominant and non-dominant sides and between groups were compared using the paired t-test and Student's t-test. Pearson's correlation coefficient was used to reveal the relationship between hip abductor and adductor muscle strength. Results with  $p < 0.05$  were considered as statistically significant.

#### RESULTS:

Hip abductor muscle strength on the non-dominant side was higher than on the dominant side ( $309.4 \pm 52.5$  N vs.  $285.5 \pm 47.6$  N,  $p < .001$ ). Hip adductor muscle strength was not significantly different between the non-dominant and dominant sides ( $273.5 \pm 49.8$  N vs.  $279.0 \pm 50.6$  N,  $p = .263$ ). Hip abductor muscle strength was associated with hip adductor muscle strength (dominant side:  $r = .663$ ,  $p = .001$ , non-dominant side:  $r = .528$ ,  $p = .001$ ). Eight subjects developed groin pain. Hip abductor muscle strength in the groin pain group was not significantly different from that in the control group ( $300.9 \pm 46.8$  N vs.  $268.0 \pm 34.1$  N,  $p = .058$ ). Meanwhile, hip adductor muscle strength in the groin pain group was significantly lower than that in the control group ( $243.3 \pm 32.9$  N vs.  $280.1 \pm 45.3$  N,  $p = .029$ ).

#### CONCLUSION:

Football players experience hip muscle imbalance. Hip adduction weakness during pre-season is a risk factor for groin injuries. Hip adduction training is important to prevent groin injuries and to continue playing football during the season.

## LOWER LIMB KINEMATIC CHARACTERISTICS DURING OBSTACLE STEP-OVER IN INDIVIDUALS WITH GLAUCOMA

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#### INTRODUCTION:

Many reports have predicted that the total number of people with visual difficulties is expected to rise for a highly ageing society. By 2030, the number of people with moderate or severe visual impairment is projected to reach 300 million. People with low vision face a major challenge of independent mobility. Several factors contribute to this mobility issue such as lack of information on the surrounding environment, orientation to the environment, and lack of information on barriers. In addition, visual fields are required to accurately recognize and avoid obstacles in daily life and sports situations. Therefore, a support based on the relationship between the visual field and obstacle-straddling movements is necessary. This study aimed to compare the characteristics of foot trajectory patterns during obstacle step-over between individuals with normal or corrected vision and those with visual impairment.

#### METHODS:

The normal vision group comprised 10 men ( $40.7 \pm 3.8$  years) with normal or corrected vision, while the visually impaired group comprised 10 men ( $42.6 \pm 6.2$  years) with glaucoma. Both groups performed two obstacle step-over conditions (heights of obstacles: 4 cm and 15 cm) from a free position. The step patterns for each condition were recorded using a high-speed camera at 250 frames per second. Gait parameters, such as step length, and characteristics of the foot trajectory, such the highest points of the leading and trailing feet while stepping over the obstacle, were analyzed. The coefficient of effort (the ratio of the highest point of the leading foot to the height of the obstacle) was calculated. The Mann-Whitney U test was used to assess differences between the two groups for each condition.

#### RESULTS:

The visually impaired group had significantly advanced initiation of the step-over motion and increased step length in both conditions ( $p < 0.05$ ) when compared to the normal vision group. Furthermore, the highest points of the leading feet while stepping over the obstacle were significantly higher ( $p < 0.05$ ) in the visually impaired group. Moreover, the coefficient of effort in the visually impaired group was significantly larger ( $p < 0.05$ ) than that in the normal vision group.

#### CONCLUSION:

Visual feedback information allows individuals with normal or corrected vision to perform obstacle step-over conditions steadily with minimal effort. In contrast, individuals with visual impairment spend more time and effort during obstacle step-over to ensure a safer trajectory path and a lower trip and fall risk. Glaucoma is a disease caused by damage to the optic nerve, resulting in visual field constriction and visual field defects. Therefore, in Glaucoma, it is difficult and more challenging to identify an obstacle at a farther distance or when moving towards the obstacle. These results suggest that this is a characteristic obstacle avoidance behavior in patients with visual field defects.

## HEALTH AND FITNESS

### THE FEASIBILITY OF A NOVEL 12-WEEK GROUP FITNESS PROGRAM IN CANCER PATIENTS AND SURVIVORS: A PILOT STUDY.

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#### INTRODUCTION:

There is good evidence for positive physical and psychological effects of physical activity in cancer patients. Reducing cancer-related fatigue, increasing patients strength and endurance, and improving quality of life are some merits of exercise interventions that can alleviate common side effects of cancer treatment. However, adherence to exercise interventions is often low.[1] Therefore, the aim of this pilot study was to evaluate the feasibility of a novel supervised group fitness program with a focus on community, music, and play.

#### METHODS:

Ten cancer patients ( $59.9 \pm 14$  years,  $77.9 \text{kg} \pm 10 \text{kg}$ ,  $5 \text{f}/5 \text{m}$ ) voluntarily participated in a 12-week supervised group fitness program. The program took place once a week for a duration of 60 minutes each session. It contained strength, coordination, and endurance elements with a focus on one of these elements changing every month. Two investigations at baseline (t0) and after the intervention (t1) period were conducted including strength tests (leg and chest press, lat pull), coordination tests (10m balancing, one-legged stance, step-ups, stair climb test), and completing questionnaires (Borg Scale and SF-36). Depending on data distribution, paired sample t-test or Wilcoxon-test were applied.

**RESULTS:**

The Program led to an overall adherence of 69%. One person dropped out without stating a reason. An average of 13.4±1.8 on the Borg Scale was reported. Coordination skills in balancing forward (t0: 9.5s±3s, t1: 6.8s±2s, p=0.007) and backwards (t0: 22.1s±12s, t1: 14.9s±7s, p=0.003) improved. One-legged stance time increased in the right (t0: 67.7s±41s, t1: 79.3s±33) and left (t0: 74.3s±42s, t1: 78.2s±34) leg without statistical significance. Time needed for the step-up test (t0: 17.7s±4s, t1: 15.1s±3, p=0.004) improved as well as in the stair climb test (up t0: 2.68s±0.7s, t1: 2.6s±0.7, p=0.502; down t0: 2.71s±0.7s, t1: 2.4s±0.5, p=0.022). Strength parameter improved in leg press (+23kg±20.3kg, p=0.009), chest press (+5kg±5.7kg, p=0.03), and in lat pull (+2.3kg±6.6kg, p=0.324). SF-36 physical (+4.4±8.2) and psychological (+7.5±13.6) score improved without statistical significance.

**CONCLUSION:**

Overall, the program was well tolerated. Content and the acting process of the course were feasible and no serious adverse events emerged. This feasibility study demonstrated that strength, coordination, and quality of life improved in cancer patients and survivors. However, compliance rate was only average due to the limited course offer once a week. Participants asked for a more flexible schedule with multiple sessions a week. Implementing the program within the fitness centre is advisable and health care authorities should support the program for cancer patients. Given the feasibility, a prospective RCT for an extensive evaluation of the program is planned.

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**TRAINING ON INSTABLE SURFACES**

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**INTRODUCTION:**

In recent years, there has been a growing number of papers in sports- and health-science literature examining the effects of an inactive, sedentary lifestyle. Numerous tools and methods are emerging in the 'health market' to help the modern, 21st century people maintain, and if necessary, regain their health, thereby increasing the number of years they live healthy. The conclusions and recommendations of these articles emphasize the importance of prevention as well. Training on instable surfaces (for example, on bosu, balance cushion, etc.) can contribute to the development of the body stabilizers (core muscles) and therefore this kind of training has been emerging as a preventive exercise. All of these devices provide an instable platform only if placed on a hard surface. The use of water as an instable training environment is less common nowadays. This research focuses on changes in heart rate during exercises performed on instable devices placed on stable ground (such as balance cushions placed on the ground) and on devices placed on instable water surface (aquapaddle in a pool).

**METHODS:**

The heart rate measurements were conducted in November 2019, in a 25-meter swimming pool in the wellness department of Sárvárfürdő Spa, and in the gym of the Institute of Sport Sciences in Szombathely. In the swimming pool, the aquapaddles were attached to the pool edge and to the pool lane divider ropes. The ground exercises were performed in the gym. The participants were randomly selected from the sports students of the Institute of Sport Sciences (N=9). The same exercises were performed in both environments: two 20-minute sessions in each, led by a PE teacher. In the first session, the participants performed static exercises, while in the second one, exercises that are more dynamic. The changes in heart rate were measured using the Polar Pro Team system. Prior to each session, a chest strap suitable for heart rate measurement was attached to the participants. The measurements started at the beginning of the sessions and stopped immediately after the last exercise. We monitored heart rate changes by the pool and in the gym using a tablet device

**RESULTS:**

The results of the aquapaddle session have been assessed and the comparison of the participants static heart rate and their heart rate measured during the dynamic exercise indicates that there was a significant difference only in 80-89% of maximum heart rate (p<0.03) and 90-100% of maximum heart rate (p<0.00), in favor of the dynamic exercises. There was no significant difference in either the amount of calories burned or the recovery time.

**CONCLUSION:**

Next, we would like to compare the heart rate values obtained from the ground exercises and the aquapaddle exercises, as it is assumed that due to the continuous stabilizing effort, participants had a higher heart rate in aquapaddle exercises than in the exercises with instable device placed on stable ground

**THE EFFECTS OF SAUNA SÉANCES ON THE SAUNA MASTER'S HEART RATE**

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**INTRODUCTION:**

The beneficial effects of sauna on body and soul have been proven by numerous studies. To enhance the sauna experience, we can take part in sauna séances run by sauna masters. In a sauna séance, the sauna master increases the heat intensity from 80 to 90 °C to up to 100 to 110 °C in 12 to 15 minutes using various ventilation techniques, water and ice. The purpose of this study is to investigate how the circulatory system of the sauna masters is affected by approximately 12 to 15 minutes of sauna activity in an 80-100 °C environment.

Depending on the work schedule, sauna masters have 2 to 3 séances a day and 8 to 10 a week. Based on this it can be concluded that their body has adapted to high temperatures, thus it is assumed that despite working in a nearly 100 °C environment, the heart rate of sauna masters does not rise above 80 to 85% of their maximum heart rate. Our work was realized by EFOP-3.6.1-16-2016-2018 competition.

**METHODS:**

The study was conducted on November 1-3, 2019, with 5 sauna masters (3 women, 2 men; age: 26,8±3) of the wellness department of Bükfürdő Thermal and Spa in Bük, Hungary. The heart rate changes of the sauna masters were measured using the Polar Pro Team chest strap system, suitable for heart rate measurement. Before the sauna séance, the chest strap was placed on the sauna masters. We started the measurement at the beginning of the séance and stopped it right after it ended. Heart rate changes were monitored on a tablet device outside the cabin. The data was processed using SPSS software package.

**RESULTS:**

The average maximum heart rate of the sauna masters was  $203.6 \pm 13.92$ . During the 12-minute and 18-minute séances the average heart rate of four sauna masters was between 90 to 100% of maximum heart rate in most of the time spent in the cabin (in 33 to 61% of the total time). The fifth sauna master had also in this heart rate zone for 14% of the cabin time.

There was a correlation between the duration of the sauna séances and the time spent in the 80 to 90% heart rate zone ( $p=0.1571$ ), as well as between the duration of the sauna séances and the time spent in the 90 to 100% heart rate zone ( $p=0.0380$ ). The longer the sauna séance lasted, the longer the sauna masters had a pulse rate of 80 to 90% of their maximum heart rate, and the less time they spent in the 90-100% heart rate zone. A training load score was in a significant correlation with the recovery time ( $p=0.0075$ ). Furthermore, there was a noticeable correlation between the training load score and calories burned ( $p=0.0233$ ).

#### CONCLUSION:

Sauna masters reached and even exceeded 90 to 100% of their maximum heart rate, regardless of gender or age. Sauna masters need more recovery time (6.3 to 15.3 hours) than what they actually have between séances (2 to 3 a day). Thus, it could be worth examining the changes in heart rate during successive séances.

### THE EFFECT OF TRANSIENT EXERCISE ON THE LEVELS OF ADVANCED GLYCATION END-PRODUCTS AND RELATED MARKERS IN YOUNG WOMEN

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#### INTRODUCTION:

Advanced glycation end-products (AGEs) are harmful compounds formed through an excess of protein and sugar in the human body. Excessive accumulation of AGEs has been reported to accelerate the aging process and contribute to diseases such as arteriosclerosis and diabetes. A known precursor to AGEs production is glycated hemoglobin A1c (HbA1c), a combination of sugar and hemoglobin in the body. When blood glucose is high, the production of HbA1c increases. Few studies have experimentally verified the relationship between skin AGEs and acute exercise. Therefore, this study investigates whether skin AGE and blood HbA1c levels change following a single exercise session.

#### METHODS:

The participants were healthy female aged 20-26. A diagnostic tool called the TruAge scanner was used to measure AGE levels by measuring the amount of AGEs accumulated on the skin. The exercise load was set at a target heart rate of approximately 70% and participants were asked to run on a treadmill for 30 minutes. On the day before the experiment, participants were instructed to limit drinking and have dinner by 21:00. On the day of the experiment, the participants were instructed to not eat anything and to only drink water. Set breakfasts and lunches were given to each participant. The same participant was measured on two different days under different experimental conditions: (1) The control was 30 minutes resting in a seated position and (2) measurement after 30 minutes of running on a treadmill at 70% exercise intensity. The skin AGE values, blood glucose levels, and blood HbA1c levels were measured before, immediately after, and six hours after each condition. Saliva was also collected to measure salivary cortisol.

#### RESULTS:

At a 70% exercise intensity load, the values of HbA1c did not change significantly before and after exercise. The skin AGE levels were equal both before the exercise session and six hours post-exercise. The sharpest decrease in skin AGEs occurred within 10 minutes after finishing the exercise.

#### CONCLUSION:

The increase in the AGEs levels immediately after exercise may have been because of the accumulation of sweat on the skin's surface. In future studies, it is necessary to take the measurement conditions into account. However, the findings confirmed that the blood HbA1c and skin AGE levels did not fluctuate much during transient exercise.

### HIIT TRAINING: EFFECT ON BLOOD PRESSURE IN OLDER ADULTS

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#### INTRODUCTION:

In recent years there has been evidence of an increase in chronic non-communicable diseases (NCDs) such as high blood pressure, which, it is estimated that 1 in 3 people over 65 suffer from this disease. Around 9.4 million people die from this pathology and it is projected to be the fourth cause of mortality by 2030 [1]. There are pharmacological treatments for high blood pressure, but there is also a non-pharmacological treatment such as healthy eating and regular practice of aerobic, strength or combined physical exercise [2]. High performance training as HIIT has been postulated for the treatment of this pathology in different populations [3], however, there is little scientific evidence in older adults. Therefore, the aim of this study is to determine the acute effect, after 24, 48 and 72 hours of HIIT type training on blood pressure in older adults from the physical exercise program. We also, hypothesized that could be a preventive treatment for hypertension in older adults.

#### METHODS:

Nineteen physically active older adults: 18 women and 1 man, with an average age of  $68,63 \pm 4,9$  years, without any pathology were worked out with a unique session of high intensity interval training (HIIT) and were assessed using the Physical Activity Scale for the Elderly. Blood pressure (BP) was measured before, after, 24, 48 and 72 hours after intervention. Values are expressed as mean $\pm$ S.D. Differences between groups were assessed by one-way analysis of variance (ANOVA).

#### RESULTS:

At baseline, value of BP before intervention was  $119,4 \pm 12,8 / 72,6 \pm 7,7$  mmHg. A non-significant decrease was observed after session ( $115,4 \pm 8,5 / 66,9 \pm 5,8$  mmHg), at 24 ( $114,3 \pm 7,2 / 66,1 \pm 4,7$  mmHg), at 48 ( $110,7 \pm 7,3 / 65 \pm 5,2$  mmHg) and at 72 ( $117,1 \pm 11 / 66,7 \pm 5,4$  mmHg).

#### CONCLUSION:

Although a significant decrease in BP is not observed, there is a tendency to decrease. More studies are needed to better understand the effects of HIIT on BP and how to apply this type of training

**EFFECT OF AGE ON FUNCTIONAL FITNESS IN FAFE ACTIVE ELDERLY. A PILOT STUDY.**

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**INTRODUCTION:**

Exercise has a positive association with maintenance of functional fitness, and therefore, an important role in the mobility, autonomy, health and welfare of elderly adults. Consequently, the purpose of this study was to analyze the effects of age on some functional-fitness parameters in Fafe active elderly.

**METHODS:**

Fifty seven elderly subjects from a physical activity program of Fafe city hall were divided in two age groups: i) young elderly (YE): 60-65 years old and ii) elderly (E): 65 years old and over. The functional fitness evaluation included body mass index (BMI, kg/m<sup>2</sup>), lower body strength, agility and dynamic balance, flexibility and endurance, as described in the "Older adult fitness battery/The senior fitness test" by Rikli and Jones (1999) [1].

**RESULTS:**

Although no differences were observed among age groups in strength, agility and dynamic balance, in flexibility and endurance capacity YE has shown better results than the E group (-8,4 ± 8,3 vs -9,6 ± 9,0 and 130,3 ± 19,6 vs 126,6 ± 22,7). Regarding metabolic health both groups have shown to be overweight (28,3 ± 4 and 28,4 ± 3,3).

**CONCLUSION:**

Considering that flexibility and endurance capacity are compromised with aging, even in active subjects, these functional parameters should be reinforced in elderly exercise programs. Moreover, metabolic exercise strategies should be analyzed in terms of intensity and volume in order to reduce the observed overweight.

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**RELATIONSHIP AMONG WALKING TIME, SITTING TIME, WEIGHT LOSS AND STRENGTH AFTER A BARIATRIC SURGERY**

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**INTRODUCTION:**

The goals of this study were: to analyse the relationship among walking time, sitting time, weight loss and strength after a bariatric surgery. The patients were 11 (Mage = 36,18; SD = 9,51; 4 men and 7 women).

**METHODS:**

The patients that were intervened of Intra-gastric balloon were (n=8) and endoscopic sleeve gastropasty were (n=3). To analyse the relationship among walking time, weigh, isometric strength and body mass index a liner regression was performed, the results showed that the linear model was significant (F=11.01; p<.01; R<sup>2</sup>=.9).

**RESULTS:**

The only significant relationship found was between the number of days walking at least ten minutes a week and the weight before the surgery which reported that the higher the days of walking at least ten minutes was, the less weight that patients had. Besides, the rest variables (weight after intervention, strength and body mass index) did not report significant differences. On the other hand, to know if there were differences among sitting time and weigh, isometric strength and body mass index a liner regression was conducted and the model did not reported significant differences (F=2.36; p<.18; R<sup>2</sup>=.70).

**CONCLUSION:**

As a whole, walking time might be not related to weight loss and strength in an intervention of 3 months. Perhaps, walking is not enough to make improvements on strength and weigh loss variables. In addition, there may be not relationship between sitting time, weigh, isometric strength and body mass index, which means that sitting time might be not a predicted variable on the post-surgery intervention. This may be due to differences between Intra-gastric balloon and Endoscopic sleeve gastropasty surgeries.

**THE RELATIONSHIP BETWEEN LEFT VENTRICULAR CARDIAC FUNCTION WITH 3-DIMENSIONAL ECHOCARDIOGRAPHY AND TOTAL CEREBRAL BLOOD FLOW IN THE HEALTHY ELDERLY**

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**INTRODUCTION:**

Cerebral blood flow (CBF) decreases with aging, and reduced CBF is known to be a risk factor for cerebrovascular diseases and Alzheimer's disease in the elderly. Our previous study indicated that the high fitness people have a higher resting CBF in elderly women. Moreover, it is well known that the physical exercise improves cardiac function. On the other hand, the relationship between cardiac output (CO) and CBF has been shown in healthy individuals and patients with heart failure. Previous studies reported that low CO was related with low CBF in the elderly. Therefore, the cardiac function may play an important role in maintenance of CBF. However, the relationship between left ventricular (LV) function and CBF is still unclear. The purpose of this study was to test our hypothesis that the LV function would be associated with CBF in the healthy elderly.

**METHODS:**

Thirty-two healthy elderly volunteers (80±5 years old, BMI 23±3 kg/m<sup>2</sup>, 19 female) underwent three dimensional (3D) echocardiography (EPIQ7, Philips) and carotid ultrasound (vivid i, GE) evaluation in the supine position at rest. We excluded subjects with past stroke (cerebral infarction or/and hemorrhage) and cardiovascular disease. End-diastolic volume (EDV), end-systolic volume (ESV), stroke volume (SV), ejection fraction (EF), global longitudinal strain (GLS), global circumferential strain (GCS) and twist were estimated as LV function indices with 3D LV volume curve constructed by using automatic detection of endocardium with commercial software (LV Analysis 3.1, TomTec). CO was calculated by SV × heart rate. The blood velocity and diameter in the both right and left internal carotid (ICA) and vertebral arteries (VA) were measured using a Doppler ultrasound. The blood flow was calculated by  $\pi \times (\text{mean vessel diameter} / 2)^2 \times \text{blood flow velocity}$ .

The sum of blood flow of the both right and left ICA and VA was evaluated as total cerebral blood flow (TCBF). The multiple linear regression analysis was performed using TCBF as independent variables, and age, sex and each LV function as dependent variables.

**RESULTS:**

EDV, ESV, SV, EF, GCS, twist and CO were not correlated with TCBF. In contrast, GLS was significantly correlated with TCBF ( $B=-9.78$ ,  $P=0.02$ ).

**CONCLUSION:**

CO was not correlated with TCBF in this present study, contrary to a previous study. This discrepancy may be attributable to difference in evaluation methods of CBF. Present results indicated that GLS may play more significant role for resting CBF in the healthy elderly as compared with other LV function.

## ASSOCIATIONS OF EXERCISE HABITS WITH BODY COMPOSITION AND PHYSICAL FITNESS IN NON-OBESE YOUNG MEN

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**INTRODUCTION:**

Exercise habits are important to prevent non-communicable diseases. On the other hand, increased non-physical activity time is pointed out in young individuals.

In general, on attending college, an individual's lifestyle drastically changes and may occasionally trigger quitting of sports activities. The non-exercise habit, even if for a short period, may facilitate the development of a negative change in physical fitness in young, non-obese men. Hence, we hypothesized that exercise habits would affect body composition and decrease physical fitness and pulmonary function in non-obese men attending college.

**METHODS:**

Fifty-two male university students participated in this study. They answered a questionnaire about exercise habits and history. Their body composition was assessed using impedance method: weight, body mass index (BMI), %fat mass, fat mass, lean body mass (LBM), and muscle mass. Physical fitness was evaluated based on the physical fitness test of the Ministry of Education, Culture, Sports, Science and Technology in Japan, which involved grip strength, sit up, sit and reach, side step, and standing long jump (Jump). Pulmonary function, forced vital capacity (FVC), forced expiratory volume 1 (FEV1), FEV1/FVC, and peak expiratory flow(PEF)were determined using a spirometer.

**RESULTS:**

The average age, height, weight, and BMI were  $18.9\pm 0.9$ y,  $169.2\pm 5.9$  cm,  $58.4\pm 9.0$  kg, and  $20.3\pm 2.8$  kg/m<sup>2</sup>, respectively. Eleven subjects had exercise habits, but forty-one subjects did not continue these or did not have them. We divided the subjects and analyzed three groups: exercise habit (n=11; Ex), non-exercise habit (n=28; non-Ex), quit exercise habits within less than a year (n=13; quit-Ex). Their weight and muscle mass were significantly higher in the Ex group compared with those in the non-Ex and quit-Ex groups: weight ( $64\pm 9.8$  kg (Ex),  $57.7\pm 9.0$ kg (non-Ex), and  $55.3\pm 6.8$ kg (quit-Ex)), LBM( $53.8\pm 7.0$ kg (Ex),  $48.4\pm 5.1$ kg (non-Ex), and  $43.7\pm 6.0$ kg (quit-Ex), and muscle mass ( $51.0\pm 6.7$ kg(Ex),  $45.9\pm 4.8$ kg(non-Ex), and  $44.8\pm 5.7$ % (quit-Ex)). Height, BMI, %fat mass, and fat mass were not different among the groups. Physical fitness test and pulmonary function were not significantly different among the groups. Meanwhile, muscle mass was significantly correlated with grip strength ( $r=0.44$ ), sit-up ( $r=0.29$ ), Jump( $r=0.35$ ), FVC ( $r=0.62$ ), %FVC ( $r=0.37$ ), FEV1 ( $r=0.53$ ), %FVC ( $r=0.28$ ), PEF ( $r=0.58$ ), and %PEF ( $r=0.42$ ).

**CONCLUSION:**

Exercise habits in non-obese young men were significantly low muscle mass despite no difference in fat mass. In addition, the body composition was associated with physical fitness and pulmonary function. The low muscle mass in young men may promote risks in health in the future.

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## EFFECTS OF PHYSICAL FITNESS ON DIVING BRADYCARDIA IN MIDDLE AGED JAPANESE MEN

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**INTRODUCTION:**

The autonomic nervous system plays an important role in maintaining health. A decline in parasympathetic regulation leads to the development of cardiovascular diseases [1]. Autonomic function is associated with physical fitness. Particularly, heart rate variability and heart rate recovery (HRR), indicators of parasympathetic regulation, are greater in high-fitness group than in low-fitness group [2]. A diving reflex test can also evaluate parasympathetic regulation, and it is short (30-60 s), simple, and relatively safe to perform. This test only requires facial cooling and breath-holding, and these stimulations induce diving bradycardia. However, the effects of physical fitness on diving bradycardia have not been determined, especially in middle aged people. This study aimed to examine the effects of physical fitness on diving bradycardia in middle aged Japanese men.

**METHODS:**

In this study, 43 men (age: 40-59 years) were recruited from "Waseda Alumni's Sports, Exercise, Daily Activity, Sedentariness Health Study" from 2015 to 2018. The diving reflex test was performed for all participants in the sitting position, with their faces immersed in cold water (temperature: 2-5°C) and with breath-holding for 30 s, prior to a graded exercise test. R-R intervals were recorded before and during the diving reflex test to determine maximal bradycardia. The graded exercise test was performed to determine peak oxygen uptake (VO<sub>2</sub>peak) and HRR using a cycle ergometer. HRR was defined as the reduction in the heart rate from the rate at peak exercise to the rates 1, 2, and 3 min after the cessation of exercise (HRR1, HRR2, and HRR3). Participants were divided into two groups: High-fitness group (VO<sub>2</sub>peak,  $40.8 \pm 3.9$  ml/kg/min, n = 21) and Low-fitness group (VO<sub>2</sub>peak,  $29.5 \pm 3.3$  ml/kg/min, n = 22) according to the reference values for cardiorespiratory fitness for health promotion, issued by the Ministry of Health, Labor, and Welfare of Japan.

**RESULTS:**

There were no significant differences in body mass index and body fat percentage between the groups. Maximal R-R interval during the diving reflex test was longer in the High-fit group than in the Low-fit group ( $1724.0 \pm 651.2$  and  $1380.6 \pm 796.7$  ms, respectively,  $P = 0.005$ ).



HRR1 did not differ between the groups ( $P = 0.15$ ), but HRR2 and HRR3 were significantly higher in the High-fit group than in the Low-fit group ( $P = 0.002$  and  $P = 0.006$ , respectively).

#### CONCLUSION:

The present study suggests that physical fitness is related to parasympathetic function measured by the diving reflex test as well as HRR in middle aged Japanese men. The diving reflex test may provide valuable information on autonomic function.

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### IMPACT OF AN ADAPTED PHYSICAL ACTIVITY PROGRAM ON THE SURVIVAL OF PATIENTS WITH DIFFUSE LARGE B-CELL LYMPHOMA: A STUDY PROTOCOL

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#### INTRODUCTION:

The positive impact of physical activity on survival has already been demonstrated in lymphoma patients before and after treatment<sup>1</sup>. However, few studies have concomitantly associated the practice of adapted physical activity (APA) with chemotherapy treatments.

The risk of relapse of patients with diffuse large b-cell lymphoma (DLBCL) is 40% within 24 months of treatment<sup>2</sup>.

“R-CHOP” treatment is the 1st line standard treatment and no associated molecule has yet shown superiority in survival<sup>3,4</sup>.

This study aims to evaluate the impact on survival of an APA program supported during the 1st line treatment of patients with DLBCL over 65 years old.

#### METHODS:

It is a phase III, randomized, national, multicenter, and prospective trial.

Upon the announcement of the disease and at regular intervals, patients will be evaluated on anthropometric data, advanced blood tests, on their muscle mass (CT scan), as well as on various functional abilities such as handgrip tests, SPPB test and several questionnaires about quality of life, autonomy, fragility, and nutrition.

#### RESULTS:

##### Expected results

168 patients will be recruited in this trial. We expect to increase the event-free survival of patients evaluated at 24 months. We will also evaluate, during the treatments, the adherence of the patients to the APA program, the incidence of sarcopenia, the nutritional state, the autonomy and the quality of life of the patients.

#### CONCLUSION:

This trial could provide a significant level of evidence on the beneficial implementation of an APA program in a public with DLBCL. This by improving/maintaining muscle mass and abilities, quality of life for patients, reducing the incidence of comorbidities and ultimately improving survival.

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### THE INDEPENDENT AND COMBINED EFFECTS OF A 16-WEEK EXERCISE AND BCAA SUPPLEMENTATION ON FRAILTY AND MOOD STATES OF OLDER WOMEN

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#### INTRODUCTION:

The frailty syndrome (FS) is characterized by a multifactorial clinical syndrome influenced by environmental and biological factors. The progressive losses of functions that occur in the body and consequently physical function decrease are hallmarks of this negative process (1). Some studies have shown that regular exercise has positive effects on several factors correlated with frailty (i.e. physical, psychological) in elderly persons (2). Current findings shown that protein supplementation together with exercise seems to be more effective in decreasing frailty, in promoting muscular mass and strength, in improving functional capacity as well as psychological health (2). Although many nutrients have been tested, (BCAA) showed more promising results. The aim of this study was to analyse the isolated and combined effects of BCAA supplementation and exercise on physical frailty status and mood states in pre-frail institutionalized older women

#### METHODS:

The sample consisted of 35 female participants (age =  $83 \pm 3.21$ ) from four social care institutions. A multicomponent exercise (ME) and BCAA was carried out during 16-weeks, following the four-arm experimental design: group 1 (ME+BCAA, n= 8); group 2 (ME, n= 8); group 3 (BCAA, n=6) and control group non-exercising (CGne, n=13). To assess the five criteria of the frailty, we used Fried’s scale (1) that assesses: a) gait speed of 4,6 meters; b) non-Intentional weight loss; c) hand grip strength; d) Subjective perception of exhaustion and e) low levels of physical activity. This protocol classifies individuals as frail, pre-frail or robust. The (POMS) and the (GDS) scale were also applied. In addition, the SPPB was applied. All the tests were applied before and 16-weeks after the exercise program. The (CGne) did not alter their usual routine. Comparative (T-test and Wilcoxon) and effect size (Cohens’ d) statistical analysis was performed.

**RESULTS:**

After 16 weeks, both BCAA+ME and BCAA groups showed improvements in SPPB performance and decreased frailty ( $p < 0.05$ ) with a moderate size effect ( $d < 0.30$ ). In the BCAA+ME a moderate effect size ( $d=0.44$ ) was also found towards more positive mood states.

**CONCLUSION:**

Our study revealed that exercise plus BCAA supplementation was able to improve physical and psychological health, corroborating previous findings that found satisfactory results in physical function explained by the protein synthesis effect. Moreover, the trend for the improvement of mood states may be related to the effect of BCAAs in increasing serotonin levels modulated by exercise (2).

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**MAXIMAL AEROBIC CAPACITY IN ELITE ATHLETES OF ENDURANCE DISCIPLINES**

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**INTRODUCTION:**

In the exercising human, maximal oxygen uptake ( $\dot{V}O_{2max}$ ) is limited by the ability of the cardiorespiratory system to deliver oxygen to the exercising muscles. The aerobic capacity is determined as maximum oxygen uptake ( $VO_{2max}$ ) is defined as the highest rate at which oxygen can be taken up and utilized by the body during severe exercise. It is one of the main variables for estimation of the cardiorespiratory fitness and sports performance in endurance events. The purpose of this study was to study the correlation of physiological factors that limit  $VO_{2max}$  and determining the role of this variable in endurance performance.

**METHODS:**

263 athletes (197 males and 66 females) of endurance events (biathlon, rowing, football, canoe, boxing) volunteered to participate in this study with according to the principles of the Declaration of Helsinki after providing informed consent. Subjects performed a maximal incremental exercise test on a treadmill ergometer (LE 500 CareFusion) to achieve the maximal oxygen uptake ( $VO_{2max}$ ).  $VO_{2max}$  was determined as the highest 30-s value achieved during the test. Respiratory data were analyzed breath-by-breath using spirometric Oxycon Mobile (Jager, Germany) and expressed at STPD.

**RESULTS:**

The mean value of  $VO_{2max}$  determined in males was  $56,3 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$ , with highest  $VO_{2max}$  at biathletes –  $63,6 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$  and lowest value at boxers –  $52,8 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$ ; the mean value in females  $50,2 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$  with highest value at biathletes –  $55,2 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$  and lowest at rowers –  $42,0 \text{ ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$ . The achievement of the  $VO_{2max}$  was associated with increasing such physiological parameters: heart rate – 2.6 times; pulmonary ventilation – 9.3 times, cardiac output – 3.5 times, stroke volume – 1.5 times and  $a\text{-}VO_{2}$  – 2.2 times.

**CONCLUSION:**

In this study were determined the significant correlated with  $VO_{2max}$  and maximal cardiac output ( $r = 0.67$ ;  $p \leq 0.001$ ), stroke volume ( $r = 0.59$ ;  $p \leq 0.001$ ), pulmonary ventilation ( $r = 0.55$ ;  $p \leq 0.001$ ), oxygen pulse ( $r = 0.59$ ;  $p \leq 0.001$ ) as also with maximal power ( $r = 0.76$ ;  $p \leq 0.001$ ).

**EFFECTS OF SNPE PROGRAM ON FORWARD HEAD POSTURE CORRECTION AND NECK PAIN RELIEF**

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**INTRODUCTION:**

Forward head posture (FHP) refers to the head ahead of the body's gravity line. This results in a long-term neck muscular stress resulting in local pain-related muscle spasms, trigger points, and/or referred pain. The close relationships between FHP and neck pain in adults has been repeatedly demonstrated and various methods for solving problem have been suggested. Self Natural Posture Exercise (SNPE), designed in Korea, uses unique exercise tools and body correction belts to release muscle tension and correct unbalanced posture relieving pain. This study examined the effects of SNPE on FHP correction and neck pain relief in young women.

**METHODS:**

Twenty young women ( $28.1 \pm 6.2$  yrs,  $22.7 \pm 3.3 \text{ kg/m}^2$ ) who had cervical pain for more than 3 months prior to the study, had a total score of Neck Disability Index of 5–14 points, and had the craniovertebral angle (CVA) less than  $52^\circ$  were recruited. They were randomly and equally divided into two groups; SNPE group (SNPEG,  $n=10$ ) or non-exercise group (NG,  $n=10$ ). SNPEG participated in the SNPE Basic Program 60 min/session, twice a week for 12 weeks while NG did not for any exercise programs. The body posture was evaluated by measuring the distance from the body center line to 6 points around neck area before and after the program. CVA and the right and left acromion line were also measured. Pain perception was measured by Visual Analogue Scale at 8 trigger points. Statistical analysis was performed by paired t-test and ANCOVA.

**RESULTS:**

In posture analysis of SNPEG, the distance between the centerline and left-ear, right-ear, and right-acromion process was significantly decreased from  $58.3 \pm 22.1$ ,  $52.0 \pm 24.4$ , and  $52.7 \pm 16.7$  to  $41.5 \pm 19.9$ ,  $29.2 \pm 21.5$ , and  $29.6 \pm 28.3$  mm, respectively ( $p < 0.05$ ). In posture measures, group differences were found in left and right ear and left and right acromion process ( $p < 0.05$ ). The differences were greater in SNPEG. No differences were noticed in the measures from glabella and C7. CVA increased significantly in SNPEG from  $46.1 \pm 6.3$  to  $53.7 \pm 8.1$  ( $p < 0.05$ ) and group differences with bigger change in SNPEG were found ( $p < 0.05$ ). The balance between the right and left acromion improved in SNPEG but not statistically different. In pain perception analysis, left and right mastoid process, left and right C7, left and right upper trapezius, and left and right supraspinatus was significantly less scored from  $5.2 \pm 1.7$ ,  $5.1 \pm 1.6$ ,  $4.9 \pm 2.0$ ,  $4.6 \pm 2.3$ ,  $5.1 \pm 1.6$ ,  $5.3 \pm 2.4$ ,  $5.3 \pm 1.4$ , and  $5.5 \pm 1.7$  to  $1.0 \pm 1.2$ ,  $0.9 \pm 0.9$ ,  $1.5 \pm 1.4$ ,  $1.2 \pm 1.1$ ,  $2.0 \pm 1.2$ ,  $2.0 \pm 0.9$ ,  $2.1 \pm 1.4$ , and  $2.2 \pm 2.0$ , respectively ( $p < 0.01$ ). Group differences were found in left and right mastoid process, left and right C7, left and right upper trapezius ( $p < 0.05$ ), and the differences were greater in SNPEG.

**CONCLUSION:**

This suggests that SNPE may be an effective exercise program for FHP correction and neck pain relief in young women.

## FUNCTIONAL FITNESS OF THE POLISH SENIOR POPULATION

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### INTRODUCTION:

Dynamic and deep social and economic transformations that began in Poland and other Central European countries, resulted among others, in a more active approach to one's own life and health. One of the most important factors of positive health and well-being is physical fitness. It's really important to measure the actual functional physical fitness of elderly independent living persons to know the level and rate of its decrease which may inform about the threat of loss of functional independence. The aim of our investigations was to assess the level of functional physical fitness of Polish seniors. Research results will enable preparing an effective intervention strategy for maintaining mobility and functional independence of elderly people.

### METHODS:

Our research was cross-sectional and covered a representative of the population sample of elderly people living in Poland. The study involved 5,367 people, including 4,164 women and 1,203 men aged 60 to 93 years old. We have measured basic somatic and physical fitness features. Functional fitness was assessed using the Senior Fitness Test battery (SFT) designed and validated by R.Rikli & J.Jones. Research was conducted by university staff from Wroclaw, Krakow, Rzeszow, Warsaw, Gdansk and Szczecin.

After checking the normality of the distributions of the examined somatic features and the results of functional fitness tests with the Shapiro-Wilk method. The differences between means in the groups of age and gender were analysed using two-factor analysis of variance ANOVA with NIR post hoc test. The significance level of  $p \leq 0.05$  was adopted in all analyses.

### RESULTS:

The average values in individual SFT tests significantly decrease along with age. After age of 80 and 85 there were no sex differences. The largest deficits concern the dynamic balance and the decrease reaches 69% in men and 62% in women. A significantly higher rate of decline in aerobic capacity concerns men (43%) than women (36.9%). A clearly lower rate of loss occurs in the muscular strength of the lower and upper body and does not exceed 30%.

### CONCLUSION:

The nationwide sample of seniors that we studied can be considered as representative of the general population of elderly Poles because these are the first such extensive nationwide tests on actual physical fitness as an indirect measure for the assessment of the state of health of seniors. Therefore, the results can be used to track individual changes in physiological ageing not only in our country, but also can be used for international comparative studies. In the case of elderly people, an active approach to their own health is very important for successful ageing, but also for a significant reduction in the financial expenditure allocated to hospitalisation and treatment of this social group.

## THE ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND PRIMARY DYSMENORRHEA IN FEMALE COLLEGIATE LACROSSE ATHLETES

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### INTRODUCTION:

Primary dysmenorrhea is cramping lower abdominal pain during menstruation in the absence of underlying pathology and is one of the most common gynecological disorder in young women. It can cause absenteeism and affects quality of life in young women. There are several non-medicinal methods for improving this complication and increasing physical activity has been recommended for primary dysmenorrhea. The previous our research indicated that young Japanese women with severe dysmenorrhea had low level of total physical activity. However, the association between physical activity and dysmenorrhea in athletes who do more moderate to vigorous intensity physical activities than non-athletes is not known. The present study was conducted to investigate the relationship between physical activity and primary dysmenorrhea in female collegiate lacrosse players.

### METHODS:

Self-administered questionnaire which included menstrual pattern, dysmenorrhea score, and lifestyle habits was used to collect data from 70 female collegiate lacrosse athletes aged 18–22 years. All subjects were divided into three groups according to dysmenorrhea score: score 0 was non-dysmenorrhea group (Non; n=22), score 1–2 was mild dysmenorrhea group (Mild; n=35), and score over 3 was severe dysmenorrhea group (Severe; n=13). Daily physical activity was monitored using the tri-axial accelerometer.

### RESULTS:

The age at menarche was not significantly different among the three groups. No differences were observed between the groups in step counts per day, but the collegiate lacrosse athletes in the Non group had significantly longer time spent in locomotive vigorous physical activity compared with athletes in the Mild group (Non:  $11.1 \pm 6.3$  vs Mild:  $7.1 \pm 4.6$  min/day,  $p=0.025$ ). In particular, the time spent in locomotive physical activity of 8 METs or over in the Non group was significantly longer than the other two groups (Non:  $4.4 \pm 2.6$  vs Mild:  $2.2 \pm 1.6$  or Severe:  $2.5 \pm 1.7$  min/day,  $p=0.005$ ). In other hand, no difference was observed for time spent in non-locomotive physical activity among the three groups.

### CONCLUSION:

The female collegiate athletes with primary dysmenorrhea may be less physically active based on locomotive vigorous physical activity. Our results suggested that increasing locomotive physical activity than non-locomotive physical activity may be an effective treatment for primary dysmenorrhea in female athletes.

## PEDOBAROGRAPHIC STATISTICAL PARAMETRIC MAPPING REVEALS PLANTAR PRESSION SUBREGION DISCRIMINATING NEUROPATHY STAGES OF DIABETES MELLITUS PATIENTS.

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### INTRODUCTION:

Diabetic peripheral neuropathy (PN) is usually diagnosed by testing patient's sensitivity to a stimulus, but it lacks sensitivity, depends on the investigator and is time-consuming. PN patients manifest biomechanical variations during walking inducing pathologic changes in the

distribution of plantar pressure [1]. Previous studies tried to record these distributions with pedobarographic measurements, but they struggled to find pedobarographic surrogate of early PN through traditional scalar analysis. This is possibly due to spatial data reduction, which results in a great loss of information and making less sensitive the subsequent analysis [2]. Pedobarographic Statistical Parametric Mapping (pSPM), using the entire n-dimensional subsampling, can assess the whole footprint with the advantage that footprint subregions do not need to be defined a priori. Thereby, the aim of the study was to determine the effect of the diabetic PN stages on the plantar pressure distribution during gait taking advantages of pSPM method.

#### METHODS:

Participants were divided in 4 groups, matched in term of age, sex and footprint form: diabetes patients without PN symptoms (DG; n = 22); with light PN symptoms (LPN; n = 12); with severe PN symptoms (SPN; n = 6) and non-diabetic group as control (CG; n = 12). Every volunteer participated in a unique experimental session including two 10-m walking tests to calculate their spontaneous gait speed and a dynamic plantar measurement, composed of two 30-s walking trials allowing 4-10 footprints recording. Plantar pressures normalized to body mass were first extracted by traditional scalar analysis and compared using a one-way (GROUP effect) ANOVA. Afterwards, pSPM was done to compared plantar pressures among groups.

#### RESULTS:

Traditional scalar analysis highlights lower plantar pressure under the rearfoot, whose reduction increased along PN progress (-8.8% for LPN and -11.1% for SPN compared to DG). The pSPM revealed higher plantar pressure in the anterior rearfoot for the CG compared to the DG. LPN presented higher pressure in the metatarsal head and lower pressure in the posterior forefoot compared to DG and lower pressure on foot arch and heel compared to SPN.

#### CONCLUSION:

pSPM allowed to identify specific feature of plantar pressure distribution of early stage of PN that were not highlighted by traditional scalar analysis. pSPM analysis also showed that severe PN is characterized by specific plantar pressure distribution (arch collapse), clearly distinct from LPN because of foot architecture disruption. pSPM may be useful clinical screening tool, allowing to diagnose early PN and severe PN.

### FOOD INTAKE, PHYSICAL ACTIVITY AND PHYSICAL FITNESS IN NORMAL-WEIGHT AND OVERWEIGHT MEXICAN ADOLESCENTS

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#### INTRODUCTION:

Overweight prevalence is steadily increasing in Mexico (WHO)1. This study aims to assess the association of overweight with dietary intake (DI), physical activity levels (PA), and physical fitness (PF) in Mexican adolescents.

#### METHODS:

459 (259 females) adolescents from Jalisco, aged 13-17, recruited at schools, voluntarily participated in the study. Height was measured with a stadiometer (SECA 215) and weight with Inbody120. Body mass index (BMI) was determined according to WHO, which considers sex and age2. Adolescents were classified as normal-weight or overweight (normal-weight:  $\leq +1SD$  and overweight:  $>+1SD$ ;  $+1SD$  is equivalent to BMI 25 kg/m<sup>2</sup> at 19 years). Average energy intake in kilocalories (Kcal) and the energy intake distribution from carbohydrates (CH), proteins, fat and saturated fatty acids (SFA) were calculated from two 24h recalls performed by a nutritionist with visual support. A subsample of the participants (n=241) was invited to wear an accelerometer (GT3X ActiGraph) during 7 days to objectively measure time devoted to sedentary (S), light (LPA) and moderate-to-vigorous physical activity (MVPA). Upper-body muscular strength was assessed by dynamometer (Smedly); lower-body muscular strength by long jump test; explosive-strength by squat jump test; speed-agility by the 4x10m shuttle run test; flexibility by the back-saver sit and reach test and cardiorespiratory fitness (VO<sub>2</sub>max) was estimated by the 20m shuttle run test. Independent t-test were performed to compare DI, PA and PF between normal-weight and overweight adolescents. Statistical significance was accepted at  $p \leq 0.05$ . SPSS (version 25.0) was used.

#### RESULTS:

33% (87 females and 70 males) were overweight. Results indicate that there were no significant differences in DI and time in sedentary and PA between groups (Kcal intake:  $p=0.353$ ; CH:  $p=0.236$ , proteins:  $p=0.325$ ; fat:  $p=0.619$  and SFA:  $p=0.259$ ; S:  $p=0.441$ ; LPA:  $p=0.952$ ; MVPA:  $p=0.103$ ). Normal-weight adolescents got better scores in the following tests: VO<sub>2</sub>max ( $p<0.001$ ), lower-body muscular strength ( $p=0.004$ ), explosive-strength ( $p<0.001$ ) and speed-agility ( $p=0.014$ ). Overweight adolescents got better scores in upper-body muscular strength ( $p<0.001$ ).

#### CONCLUSION:

No differences were observed for DI, PA and flexibility between normal-weight and overweight Mexican adolescents. However, normal-weight adolescents presented higher levels of PF compared with their overweight counterparts. Our results could help to better design public health strategies.

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### THE "BUILDING OSTEO NEATLY EXERCISE" PROGRAMME IMPROVES GAIT ABILITY IN OLDER ADULTS WITH ACTIVITIES/INSTRUMENTAL ACTIVITIES OF DAILY LIVING DISABILITIES

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#### INTRODUCTION:

The purpose of the present study was to investigate the effects of the "Building Osteo Neatly Exercise" (BONE) programme on gait speed, plantar pressure distribution and bone strength in the foot, which were measured using quantitative ultrasound, in older adults with activities of daily living (ADL) and/or instrumental activities of daily living (IADL) disabilities.

#### METHODS:

We conducted a 4-month single-centre randomised controlled study involving 27 Japanese older adults (aged  $80 \pm 3$  years) with ADL and/or IADL disability. Participants were randomly assigned to an intervention group (IG) or a control group (CG). Those in the IG under-

went the 4-month BONE programme, which focused on foot functional training, in addition to routine activities that the nursing house typically offered to the attendees (i.e., CG activities). The fast gait speed, peak plantar pressure of the rear foot (RF) and the forefoot (FF) in the contact and propulsive phases during gait and the speed of sound (SOS) at the right calcaneus were measured at the beginning and end of the study.

#### RESULTS:

The fast gait speed, peak pressure at FF in the propulsive phase and SOS significantly increased after the BONE programme in the IG ( $p < 0.05$ ), but not in the CG. The peak pressure of the RF in the propulsive phase significantly decreased after the BONE programme in the IG ( $p < 0.05$ ). The gait speed was significantly correlated with the SOS ( $p < 0.05$ ,  $r = 0.52$ ) and peak pressure of the RF ( $p < 0.05$ ,  $r = -0.43$ ) and FF ( $p < 0.05$ ,  $r = 0.27$ ) at the propulsive phase.

#### CONCLUSION:

The BONE programme significantly improved the gait speed, bone strength in the foot and plantar pressure distribution.

### HRR AND VO2R FRACTIONS ARE NOT EQUIVALENT: IS IT TIME TO RETHINK AEROBIC EXERCISE PRESCRIPTION METHODS?

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#### INTRODUCTION:

According to current guidelines, the intensity of health-enhancing aerobic exercise should be prescribed using a percentage of heart rate reserve (%HRR), which is considered to be more closely associated (showing a 1:1 relation) with the percentage of oxygen uptake reserve (%VO2R) rather than with the percentage of maximal oxygen uptake (%VO2max) during incremental exercise (1, 2). However, the associations between %HRR and %VO2R and between %HRR and %VO2max are under debate; hence, their actual relationships were investigated in this study (3).

#### METHODS:

Data from each stage of a maximal incremental exercise test performed by 737 healthy and physically inactive participants of the HERITAGE Family Study were screened and filtered, then used to calculate the individual linear regressions (ILR) between %HRR and either %VO2R or %VO2max. For each relationship, the mean slope and intercept of the ILRs were compared to 1 and 0 (i.e., the identity line), respectively, using one-sample t-tests. The individual root mean square errors (RMSE) of the actual vs. the 1:1 predicted %HRR were calculated for both relationships and compared using a paired-sample t-test.

#### RESULTS:

The mean slopes (%HRR-%VO2R:  $0.972 \pm 0.189$ ; %HRR-%VO2max:  $1.096 \pm 0.216$ ) and intercepts (%HRR-%VO2R:  $8.855 \pm 16.022$ ; %HRR-%VO2max:  $-3.616 \pm 18.993$ ) of both relationships were significantly different from 1 and 0, respectively, with high inter-individual variability. The average RMSEs were high and revealed that the %HRR-%VO2max relationship was more similar to the identity line ( $p < 0.001$ ) than the %HRR-%VO2R relationship ( $7.78 \pm 4.49\%$  vs.  $9.25 \pm 5.54\%$ ).

#### CONCLUSION:

Since both relationships are different from the identity line and using a single equation may not be appropriate to predict exercise intensity at the individual level, a re-thinking of the relationships between the intensity variables may be necessary to ensure that the most suitable health-enhancing aerobic exercise intensity is prescribed.

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### HEMATOLOGICAL RESPONSES TO MAXIMUM AND SUBMAXIMAL ACUTE EXERCISE IN OLDERS

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#### INTRODUCTION:

Exercise is associated with hematological changes, such as the increase in hemoglobin, hematocrit and platelet number at all levels of conditioning. Acute strenuous exercise can induce a considerable and considerable decrease in plasma volume. In the elderly, during the practice of exercise large decreases in plasma volume are observed in response to exercise, this decrease, as well as the hemoconcentration caused by this decrease in plasma volume and increases in hemoglobin and hematocrit, impacts to blood flow for muscle activity and affects heart rate.

#### METHODS:

20 subjects, 13 men and 7 women ( $69.8 \pm 4.9$  years) without contraindications to exercise, 3 tests of acute physical exercise by bicycle: 1 maximum test (modified Taguchi protocol) and 2 submaximal tests at 80 % and 60% of maximum heart rate pedaling for 20 minutes. Before and after each test hematocrit, hemoglobin and plasma volume are determined to see if changes occur. It was considered as a significant value  $p < 0.05$ .

#### RESULTS:

After performing the maximum and submaximal test at 80% intensity the hematocrit concentration was significantly increased ( $44.2 \pm 3.3\%$  to  $47.8 \pm 3.9\%$  and  $43.7 \pm 3.5\%$  to  $46.7 \pm 3.1\%$ ) and hemoglobin ( $14.5 \pm 0.9$  g / dL at  $15.8 \pm 0.97$  g / dL and  $14.7 \pm 0.9$  g / dL at  $15.5 \pm 1.2$  g / dL). Plasma volume was also significantly reduced in both tests ( $-11.8 \pm 9.7\%$  and  $-11.2 \pm 7.9\%$ ). In the acute submaximal exercise at 60% intensity there was no significant changes.

#### CONCLUSION:

In olders, acute exercise by maximum and submaximal cycling at 80% of the maximum heart rate produces increases in the concentration of hematocrit and hemoglobin. Acute exercise by bicycle at 60% intensity did not change the hematological parameters of hematocrit, hemoglobin and plasma volume.

### RELATIONSHIP BETWEEN FATIGUE AND I/Q STRENGTH RATIO IN FEMALE ADOLESCENT TEAM-SPORT ATHLETES

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CONSELL CATALÀ DE LESPORT

#### INTRODUCTION:

Although the incidence of sports injuries in the adolescent population is lower than the adult, its consequences are more adverse. Muscle strength, Hamstring / Quadriceps Ratio (H/Q) and neuromuscular fatigue have been described as one of the main modifiable risk factors of suffering an Anterior Cruciate Ligament tear (1,2). The manual dynamometer has proven to be valid and reliable for measuring isometric force (3). The aim of this research was to study the effect of neuromuscular fatigue on the H/Q Ratio and the maximum isometric strength of quadriceps and hamstrings in adolescent basketball and handball female players.

#### METHODS:

This is an experimental, pre-post intervention study with a sample of 30 high-performance female athletes, 19 basketball players and 11 handball players ( $17.2 \pm 1.19$  yo  $177.8 \pm 7.2$  cm and  $68.6 \pm 9.3$  kg). To assess muscle strength, an isometric maximum strength test (manual dynamometer, MARK 10 Corporation, NY) was performed in a  $90^\circ$  hip and  $60^\circ$  knee position. Subsequently, the H/Q Ratio was calculated. The Intermittent Fatigue Test 30-15 (30-15IFT) was applied to induce fatigue, which was measured using the external fatigue perception scale (RPE).

A descriptive analysis and a T-test were performed to study the differences in the H/Q Ratio and the fatigue pre-post intervention.

#### RESULTS:

Although the H/Q Ratio decrease after 30-15IFT, differences were not statistically significant ( $p \leq 0.30$  right leg and  $p \leq 0.35$  left leg). The pre-fatigue H/Q Ratio was  $0.523 \pm 0.08$  and  $0.512 \pm 0.13$  in the right and left limb respectively and after the 30-15IFT it became  $0.506 \pm 0.09$  and  $0.508 \pm 0.13$  in the right and left limb respectively.

Regarding strength values, the right quadriceps presented a reduction of strength of 4,52% and the left quadriceps of 5.55%. The decrease of strength in both limbs were statistically significant ( $p \leq 0.05$ ), specifically 7.3% for right hamstring and 7.5% for left hamstring.

The players showed significant differences in perceived fatigue through RPE pre and post 30-15IFT ( $p \leq 0.01$ ).

#### CONCLUSION:

Similar to previous research (4), there is a tendency for knee flexors to fatigue more than extensors. Nevertheless, this decrease in the H/Q Ratio is not statistically significant, although it could have important clinical implications (5).

Even though the H/Q Ratio is not diminished post-fatigue, there is a decrease in the strength of the quadriceps and hamstrings in this female population.

In this reduction of post-fatigue strength, it is observed that the knee flexor muscles tend to fatigue more than the extensors.

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### THE IMPACT ASSESSMENT OF THE OCCUPATIONAL HEALTH PROMOTING PROGRAM AMONG EMPLOYEES AROUND SZOMBATHELY

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#### INTRODUCTION:

The status of the fat and FFM compartments is associated with and serves as established risk factors for a variety of chronic diseases from middle to old age. Body composition can also be used in assessments of functional status, disability, and mortality. Understanding the scope of the age-related changes in body composition and the factors associated with them in healthy adults will help to improve our knowledge and understanding of these processes and assist in the prevention of functional limitation and in the management of health status into old age. Numerous studies have reported age-related increases in body weight and fatness and decreases in FFM after young adulthood. Age-related decline in physical activity is associated with increased body weight and body fatness as reported in cross-sectional studies.

The aim of present study to analyze the impact of self-contained exercise and examine the pattern of age-related changes in body composition and their relations with current levels of physical activity in male and female employees.

#### METHODS:

A total of ( $n = 234$ ) adult: (94) male, ( $40.79 \pm 11.61$ ); (140) female; ( $40.92 \pm 9.18$ ) were included in the intervention-related longitudinal study; - employees of multinational companies in Szombathely and its surroundings. Before and after the six-month program, body composition was determined with a type of InBody 720 (Biospace Co. Inc., Seoul, South Korea) Bioelectrical Impedance Analyzer. On the one hand, the program included a self-contained workplace exercise that participants received via email. They also received ongoing information about nutrition. Data were analyzed with "Statistica for Windows" 13. 2 software packages. Changes in muscle mass (SMM), lean body mass by occupation and gender Repeated measures ANOVA, Post Hoc. It was analyzed by Tuckey HSD method.

The research was carried out within the framework of the EFOP-3.6.1 -16 sub-project "Complex health development program" of institutional developments for intelligent specialization.

#### RESULTS:

The total number of participants involved, for various reasons left the company (4%), illness (1%), lack of motivation (13%), decreased by a total of 18% by the end of the program. Muscle mass (SMM) in the group of males significantly increased ( $bSMM_{male} = 38.59 \pm 6.82$ - $aSMM_{male} = 39.37 \pm 4.79$ ), ( $p < 0.05$ ) Lean body mass (LBM) also decreased but only numerically. Based on education and workload, we

also found no real difference for any of the body components, and similar changes were found for fat mass (BFM) and obesity levels (OD), regardless of gender and education.

#### CONCLUSION:

Changes in the proportions of different body components varied within a relatively narrow cross-section. However, the permanent contact and the many positive feedbacks can be treated as an encouraging sign for the future. So, there has been a slow lifestyle change, and it's easier to manage.

### AN INVESTIGATION INTO THE DECISIVE FACTORS IN KEEPING A HABIT OF REGULAR EXERCISE AFTER GRADUATING FROM UNIVERSITY WITH A DECISION-TREE

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#### INTRODUCTION:

In the days of students up to university, people have the opportunity to exercise or play sports. However, after graduating, they decide for themselves whether they will keep on exercising or playing sports regularly. Individual features seem to be involved in this decision and they are thought to be associated with each other. Although multivariate analysis can be employed as a way to consider this association, it is not practical because all variables must be used to estimate the grouping. Thus, to estimate whether or not middle-aged people regularly exercise after graduating university, this study used a decision-tree which estimates the grouping with the if-then-else system but without all the variables.

#### METHODS:

A questionnaire survey including eight items on gender, age, free time in daily life, means of commuting, self-evaluation of one's own physical fitness, like or dislike of PE class at a young age, and lessons other than exercise/sports was conducted on 542 people whose age was from 23 to 40 years of age in January 2018. A decision-tree analysis was conducted for "whether regular exercise was done or not" as a dependent variable and eight questionnaire items as independent variables. Rpart function in R was used for the computation.

#### RESULTS:

As a result, a tree-structure with five layers and nine nodes was obtained. The first branch was "whether or not you did lessons other than exercises/sports," in which the people who answered "no" did not do regular exercise. The item of "Gender" was chosen as the next node and females did not do regular exercise. Those who successively chose "male," "excellent physical fitness in a self-evaluation" and "liked PE classes in student days" were categorized into a group of regular exercise. Another route consisted of "free time" and "means of commuting" and those who chose "little free time" and used public transportation to commute regularly did exercise or play sports.

#### CONCLUSION:

It is thought that many people regard exercise or sports themselves a part of cultural hobbies such as painting and tea ceremony and they enjoyed exercise or sports such as tennis and aerobics as an extension of them. In general, although females were passive, males were positive about exercises/sports and were categorized into the following two patterns: one was those who were confident in physical fitness and liked PE classes in their student days. The other was those who felt they had little opportunity to exercise or play sports because they have little free time and commute by public transportation. From these findings, for middle aged persons to enjoy exercise or sports, it is considered to be important to improve physical fitness or confidence in sports in university days as well as to add values such as "fun," "fashionable" and "smart" like cultural hobbies.

### THE FACTORS TO KEEP ON DOING REGULAR EXERCISE/SPORTS AFTER GRADUATING FROM UNIVERSITY

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#### INTRODUCTION:

University PE classes have a goal not only to improve physical fitness and/or sport skills at a young age but also to keep the participants involved with sports for their entire lives. However, although in their time at university people regularly exercise or play sports under the condition of PE classes or extracurricular sport activities, after graduation, whether or not they exercise or play sports is decided based on their own will. To investigate the measures to make people exercise/play sports, it is useful to clarify what factors are involved with this. Thus, this study statistically examined different factors discriminating between those who regularly exercise/play sports and those who do not.

#### METHODS:

The surveyed questionnaire items were eight items consisting of gender, age, free time in daily life, their means of commuting to work, a self-evaluation on their own physical fitness, their like or dislike of PE at a young age, whether or not they attend lessons other than for exercise. This surveyed was given to 542 persons aged between 23 to 40 years old in January 2018. After cross-tabulating the options of questionnaire times by whether or not they regularly exercise/play sports, a chi-square test was conducted. If a significant difference was found, a tendency was examined from significantly greater cells in a cross tab after computing standardized residuals (SR).

#### RESULTS:

As a result of the chi-squared tests, significant differences were found in "gender (chi-squared[CS] = 14.7, df = 1, p < 0.001)," "free time on weekdays (CS = 15.39, df = 7, p = 0.031)," "free time on weekends (CS = 17.06, df = 9, p = 0.048)," "I have confidence in my physical fitness (CS = 9.73, df = 3, p=0.021)" and "I have (a) lesson(s) other than sports (CS = 22.04, df = 1, p < 0.001)," indicating that there is an association with regular exercise/sports after graduation and these factors.

Furthermore, when examining each tendency from the viewpoint of their SR, males regularly did more sports than females (SR = 3.75) and those who have free time equal to or more than one hour and less than two hours on weekdays (SR = 3.75) and on weekends (SR = 3.04). However, those who answered "nine hours or more" on weekends did not regularly exercise. With regard to the question of "Do you have confidence in your physical fitness?" those who answered "yes" regularly exercise (SR = 2.62), but those who answered "sometimes" do not (SR = 2.21). Again, those who did (a) lesson(s) other than sports significantly regularly exercise (SR = 4.70).

#### CONCLUSION:

When considering from the influence of university PE classes, just “to like PE classes in their time as a student” does not lead to regular exercise/sports after graduation, and confidence of being excellent in physical fitness is not useful if incomplete but useful only when it is perfectly excellent.

#### **EFFECTS OF DIFFERENT WALKING INTENSITIES ON IMPROVING DEPRESSION IN OLDER ADULTS WITH MAJOR DEPRESSIVE DISORDER: A PILOT RANDOMIZED CONTROLLED TRIAL**

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##### **INTRODUCTION:**

World Health Organization (WHO) stated major depressive disorder (MDD) as the third leading cause of burden of disease globally in 2008 and projected it to be the first cause in 2020. Over 9% of older adults have major depressive disorders, whereas up to 37% of older adults have depressive symptoms. Currently, WHO global physical activity recommendation suggests older adults to perform 150 min moderate-intensity or 75 min vigorous-intensity aerobic-type physical activity or an equivalent combination of moderate- and vigorous-intensity activities to gain health benefits. This pilot study aimed to examine the effects of 12-week moderate- or vigorous-intensity walking exercise on improving depression in older adults with MDD.

##### **METHODS:**

In this study, older adults aged above 50 years with diagnosed MDD were recruited between January 2019 and March 2020. Participants were randomly assigned to waitlist control group (n=5), vigorous-intensity (6.5 metabolic equivalents) walking group (n=5), or moderate-intensity (3.25 metabolic equivalents) walking exercise group (n=2). The walking intervention lasted for 12 weeks and the exercise frequency was thrice a week. Beck depression Inventory (BDI) and Generalized Anxiety Disorder 7 (GAD-7) were used to measure the depression and anxiety level, respectively, at baseline and post-intervention measurement. The treatment effects were assessed using generalized estimated equation model.

##### **RESULTS:**

A decreasing trend in depression was observed in vigorous-intensity walking exercise group (p=0.051). The anxiety level was significantly reduced (p<0.05) compared with control group. There is 27.5% decrease in BDI scores and 34% decrease in GAD-7 scores in vigorous-intensity walking group compared to 3.4% decrease in BDI scores and 23.5% increase in GAD-7 scores in control group. We observed a 65% decrease in BDI scores while no change in the anxiety level in moderate-intensity walking exercise group.

##### **CONCLUSION:**

Following the WHO physical activity guidelines, our results demonstrated that 12-week walking training at either vigorous- or moderate-intensity improved depression in older adults with MDD. Walking exercise is safe, easily accessible, and cost-effective, which can be considered as a therapeutic adjuvant treatment component for older adults with MDD.

#### **HEALTH RELATED QUALITY OF LIFE IN PATIENTS WITH CANCER EXERCISING AT LOW/MODERATE VS HIGH INTENSITY DURING CANCER TREATMENT AND ONE YEAR FOLLOW UP – THE PHYS-CAN STUDY**

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##### **INTRODUCTION:**

The incidence of cancer is increasing worldwide, fortunately more effective treatments result in more people surviving cancer. The cancer treatment is associated with short and long-term side effects. Cancer survivors report a lower health-related quality of life (HRQoL) due to side effects both during and a long time after the treatment, compared to the general population. Several studies show that exercise has beneficial effects on HRQoL during oncology treatment, especially when supervised and in a combination of resistance and endurance training. The amount of exercise needed to give beneficial effect on HRQoL remains unclear. More research is needed to establish evidence-based recommendations for exercise during cancer treatment.

The aim of this study was to compare HRQoL at low/moderate (LMI) and high intensity (HI) levels of exercise vs usual care (UC) in patients with breast, colorectal and prostate cancer during (neo) adjuvant cancer treatment and up to one year follow up.

##### **METHODS:**

The Phys-Can study includes a randomized controlled trial with and a non-randomized cohort group with UC, conducted before the RCT-started. Patients with breast, prostate or colorectal cancer receiving (neo-)adjuvant treatment were randomised to HI or LMI exercise, with or without additional behaviour change support during 6-month. The exercise intervention consisted of supervised resistance training and home-based endurance training. HRQQL was assessed by the EORTC-QLQ 30 questionnaire at baseline, after 3 months, after 6 month and 1 year follow up after the intervention. Linear mixed models were used to estimate longitudinal changes of HRQoL and to compare HRQoL differences between the groups

##### **RESULTS:**

577 participants were randomized to HI (n=288) or LMI (n=289) in the RCT, and 89 participants were included in the UC-group. Results showed that combined endurance and resistance training, both on a HI and LMI can improve HRQoL compared to UC. Statistical significance were found in the global health status (3 months: HI:P=0.049 and LMI:P=0.013, 6 months: HI:P<0.001 and LMI:P<0.001, 1 year: LMI:P=0.010), role functioning (6 months HI:P=0.018 and LMI:P=0.001), emotional functioning (1 year: HI:P=0.017 and LMI:P=0.008), physical functioning (6 months: HI:P=0.028 and LMI:P=0.026), fatigue (6 months: HI:P=0.001 and LMI:P<0.001, 1 year: LMI:P=0.021) and dyspnea (6 months HI:P=0.006). We did not find any significance differences in HRQoL outcome between the different levels of exercise intensity. These findings provide important information and clinical implications for patients with cancer

##### **CONCLUSION:**

Persons with breast, colorectal and prostate cancer can be advised to exercise at either intensity level according to their personal condition without risking an improvement in health and functioning, and reduced symptoms of the cancer treatment.



## EFFECTS OF SHORT-TERM CAFFEINE SUPPLEMENTATION AND COMBINED AEROBIC EXERCISE ON BRACHIAL-ANKLE PULSE WAVE VELOCITY AND BLOOD PRESSURE IN PREHYPERTENSIVE MEN

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### INTRODUCTION:

Aerobic exercise promotes post-exercise hypotension (PEH) and decrease in pulse wave velocity (PWV). Previous studies have demonstrated that the acute caffeine supplementation eliminates this phenomenon. However, we still unknown the effect of short-term caffeine supplementation and combined aerobic exercise in pre-hypertensive men. Purpose: To examine the effect of the short-term regular caffeine consumption combined with aerobic exercise on resting brachial-ankle PWV (baPWV) and blood pressure in pre-hypertensive men.

### METHODS:

25 Pre-hypertensive male adults (age,  $26.3 \pm 4.3$  years; systolic blood pressure (SBP),  $131.5 \pm 6.5$  mmHg) were randomly assigned to caffeine group (Caf: n=13) and placebo group (Pla: n=12), in a double-blind and placebo-controlled design. The exercise session consisted of 30 min of treadmill running at intensity of 65 % heart rate reserve (HRR), 3 days/week for 4 weeks. All subjects administered caffeine (4 mg/kg) or placebo before each exercise session. During the first and final trial, baPWV and blood pressure were assessed at pre-intake (baseline), 30 min post-intake, and 30, 60, 90, and 120 min post-exercise.

### RESULTS:

At the post-exercise baPWV-AUC, before training in Caf was significantly higher than Pla, but two groups no significant difference in after training. In addition, after training was significantly decreased than before training in Caf. At the post-exercise SBP-AUC and mean arterial pressure (MAP)-AUC, before training in Caf was significantly higher than Pla, but after training in Caf was significantly higher than Pla at SBP-AUC only. In addition, after training was significantly decreased than before training in Caf at SBP-AUC and MAP-AUC. Rest of SBP and MAP at after training significantly decreased than before training in two groups (Caf: SBP reduce 5.4 mmHg, reduce degree 4.2%; MAP reduce 5.4 mmHg, reduce degree 5.6%; Pla: SBP reduce 9.3 mmHg, reduce degree 7%; MAP reduce 7.5 mmHg, reduce degree 7.9%) and there were no differences between the two groups. Rest of baPWV was not affected by training or supplementation.

### CONCLUSION:

The phenomenon of caffeine supplementation acutely increases post-exercise blood pressure and baPWV, which are improved with caffeine tolerance in regular caffeine supplementation. Aerobic exercise decrease rest of blood pressure in pre-hypertensive men, which do not be interfered by caffeine.

## THE EFFECT OF EXERCISE CLASSES FOR THE ELDERLY ON BONE DENSITY

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### INTRODUCTION:

This study focuses on the relationship between bone density and exercise habits in the elderly. We examined whether exercise such as daily steps, aerobics dance, and resistance training increased bone density. A jump was added to the aerobic dance as the impact on the bone increases bone density.

### METHODS:

The subjects of this study were 22 men and women aged 69 to 82 years old ( $74.1 \pm 4$  years old) who participated in the Senior Exercise Classroom, and 13 people participated in the measurement twice. The Senior Exercise Class was held 10 times once a week. Prior to the start of the classroom, a risk check was performed using an interview table. In the Exercise Classroom, we did warm-up, aerobic dance for 30 minutes and circuit training for 30 minutes. In the aerobic dance, jump and squat were adopted. For circuit training, push-up, abdominal curl, hip abduction, and shoulder elevation were performed.

The Bone density was measured by ultrasonic bone densitometer (OSTEO II Pro) at the first and final rounds, and the ultrasonic seeding speed (SOS value) and the standard deviation of the same age (Z score) were measured. Daily activity were measured by life code (kenz co.) and ADL TEST (JAPAN SPORTS AGENCY). Statistical processing (mean, standard deviation, t-test, and Pearson's correlation coefficient) was performed using Excel. The significance level was 5%.

### RESULTS:

The initial value was  $1358.8 \pm 110.6$  (m/s) and the final value was  $1363.2 \pm 90.6$  (m/s). There was no significant difference in bone density between the first and last rounds. However, seven people increased their score by one.

The initial value was  $0.68 \pm 1.416$ , and the final value was  $0.97 \pm 1.770$ . There was no significant difference between the first and last rounds. Many participants showed a tendency to have higher bone density than their peers.

The average activity of all participants was  $190 \pm 121$  kcal. The elderly target was 200 kcal, which was close to the target. Five participants exceeded the target. Most participants had exercise habits, but had less than 3 Mets of exercise. The average number of steps per day was  $8306 \pm 5144$ , the maximum was 20689, and the minimum was 2287. Six participants exceeded the target of 6,700 steps for men and 5,900 steps for women, as set by the Ministry of Health, Labor and Welfare. There was a correlation between the SOS value and the amount of exercise ( $r < 0.566$ ) and the number of steps ( $r < 0.574$ ). The average ADL score was  $29 \pm 6.7$ . Two or more items were high overall. 13/18 had a total score of 24 or more. Many people have high daily activities.

### CONCLUSION:

These results suggest that bone density is associated with daily activities. Older people with more daily activity showed increased bone density. Also, aerobic dance with jumps tends to increase bone density.

From these results, it was found that establishing a program focusing on the duration and exercise intensity is a challenge to increase bone density.

### **ASSOCIATION BETWEEN PHYSICAL ACTIVITY, CARDIORESPIRATORY FITNESS AND CLUSTERED CARDIOVASCULAR RISK IN SOUTH AFRICAN CHILDREN FROM DISADVANTAGED COMMUNITIES: RESULTS FROM A CROSS-SECTIONAL STUDY**

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#### **INTRODUCTION:**

Sedentary lifestyle and physical inactivity (PIA) are growing global health issues and evidence suggests that PIA is a key driver for cardiovascular and chronic diseases (Guthold, Stevens, Riley, & Bull, 2018). The current and projected physical activity levels for low socioeconomic communities from low- and middle-income countries (LMICs) are even worse (Draper et al., 2018; McVeigh, Norris, & de Wet, 2004).

We designed a cross-sectional study in the Port Elizabeth region in South Africa with the following aims. First, we described the cardiovascular health risk, PA behaviour and cardiorespiratory fitness (CRF) levels of children attending primary schools in lower socioeconomic communities. Second, we investigated whether PA and CRF are independently associated with a composite measure of children's cardiovascular health risk.

#### **METHODS:**

The study was conducted in eight quintile three primary schools located in disadvantaged communities in and around Port Elizabeth, South Africa. The present study included 650 children who had complete data records at follow-up from the DASH study (Yap et al., 2015). Children aged 10-15 years were subjected to physical activity measures, blood pressure, cholesterol, blood glucose, skinfold thickness. Cardiovascular risk markers were converted into standardised z-scores and summed, to obtain a clustered cardiovascular risk score.

#### **RESULTS:**

Overall, 650 children had complete data records. 40.8% of the children did not meet recommended physical activity levels (i.e. logged <60 min of moderate-to-vigorous physical activity per day). If quartiles were developed based on children's cardiorespiratory fitness and moderate-to-vigorous physical activity levels, a clear association of lower clustered cardiovascular risk among children with higher fitness or moderate-to-vigorous physical activity levels was observed.

#### **CONCLUSION:**

Collectively, CRF and objectively assessed PA seem to be closely linked with a composite measure of children's cardiovascular risk. Given that four out of ten South African schoolchildren do not meet international PA recommendations, efforts should be made to ensure that a physically active lifestyle is seen as an important educational goal. Concerted actions are required in South Africa to (i) improve the status of, and resources allocated to, physical education in the South African school system, and (ii) create conducive environments (e.g. teacher training in physical education) that allow and stimulate regular PA in children, which meet the prognostic importance in childhood and adolescence of critical development periods for a healthy adult life.

### **WALKING SPEED AND PREVALENCE OF LIFESTYLE-RELATED DISEASES IN ADULTS: WASEDAS HEALTH STUDY**

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#### **INTRODUCTION:**

Some epidemiological studies have investigated the relationship between walking speed and the prevalence of lifestyle-related diseases among older adults. However, the number of studies on middle aged adults is limited.

This cross-sectional study investigated the relationship between walking speed and the prevalence of lifestyle-related diseases defined as having hypertension, diabetes, and/or dyslipidemia in WASEDAS Health Study.

#### **METHODS:**

The participants in this study were 523 men (mean [SD] age 57.7 [10.6] years) and 278 women (mean [SD] age 52.4 [8.7] years) who underwent medical examinations and a walking speed test. Walking speed was measured using a digital sensor over a 6 m distance. Lifestyle-related diseases were determined using a self-administered questionnaire and the results of medical examinations. Multivariable adjusted odds ratios and 95% confidence intervals (CI) for the prevalence of lifestyle-related diseases were obtained using logistic regression models adjusting for several confounding factors. A trend test was performed to evaluate the dose-response relationship.

#### **RESULTS:**

There were 263 participants with lifestyle-related diseases (hypertension: 159, diabetes: 32, dyslipidemia: 110). The multivariable adjusted odds ratios (95% CIs) of lifestyle-related diseases for the second and third tertiles, based on the first tertile of maximum walking speed, were 1.35 (0.89–2.06) and 1.39 (0.96–2.02) (P for trend = 0.077).

#### **CONCLUSION:**

In this study, we investigated the relationship between the maximum walking speed and the prevalence of lifestyle-related diseases in middle aged men and women. Although, the second and third tertiles of the maximum walking speed groups had higher odds ratios, there was no statistical significance.

### **EFFECTS OF INTENSITY AND FREQUENCY OF WALKING EXERCISE ON IMPROVING SLEEP QUALITY IN OLDER ADULTS WITH CHRONIC INSOMNIA: A PILOT STUDY**

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#### **INTRODUCTION:**

Insomnia is a common health problem worldwide. Exercise is considered an alternative non-pharmacological aid for managing insomnia, yet how exercise frequency and intensity affect the efficacy of alleviating insomnia remains largely unclear.

The purpose of this study was to compare the effects of intensity and frequency of walking exercise on improving sleep in older adults with chronic insomnia.

#### **METHODS:**

Thirty-one older adults (aged  $\geq 50$ ) with diagnosed chronic insomnia according to the DSM-V criteria, were recruited in this assessor-blinded randomized controlled trial. Participants were randomly assigned to either the attention control group, who attended one weekly 75 minutes session of stretching exercise for 12 weeks (CON,  $n=75$ ), or one of the four walking exercise groups with the following 12-week training regimens: 1) three sessions of moderate-intensity walking exercise (MOD $\times 3$ /wk,  $n=6$ ), 2) three sessions of vigorous-intensity walking exercise (VIG $\times 3$ /wk,  $n=6$ ), 3) one session of moderate-intensity walking exercise (MOD $\times 1$ /wk,  $n=6$ ), and 4) one session of vigorous-intensity walking exercise (VIG $\times 1$ /wk,  $n=6$ ). The exercise volume of all walking exercise groups was matched. Outcome measures were conducted before and after the 12-week intervention. Pittsburgh Sleep Quality Index (PSQI) was used to assess the sleep quality and Insomnia Severity Index (ISI) was used to evaluate the insomnia severity. A lower score PSQI and ISI scores correspond to better sleep quality and lower insomnia severity respectively.

#### RESULTS:

Improvements in sleep quality were significantly larger in all exercise groups compared with CON (CON vs all exercise groups:  $p < 0.05$ ). Only groups with regular exercise patterns significantly alleviated the severity of insomnia (CON vs MOD $\times 3$ /wk and VIG $\times 3$ /wk,  $p < 0.05$ ).

#### CONCLUSION:

Our results showed that either exercise in small bouts across the week or performed all the recommended exercise volume on a single day weekly improves sleep quality in older insomniacs. However, higher exercise frequency may be required to induce beneficial adaptation on alleviating the severity of insomnia.

## WATER IMMERSION CAUSES MUSCLE CRAMP DURING MAXIMAL VOLUNTARY CONTRACTION FOR THE TOE AND KNEE FLEXORS

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#### INTRODUCTION:

Exercise associated muscle cramp (EAMC) is common among athletes. However, few study has systematically investigated the effect of possible factors such as muscle fatigue, dehydration, hot and cold environments on EAMC of the large leg muscle during voluntary muscle contraction. Our previous study showed that six of nine subjects developed EAMC of the knee flexors during maximal voluntary muscle contraction of the muscle at maximally shortened position for 15 s after a decrease in body fluid of 3% body mass by intermittent sauna exposures, but did not by intermittent cycling exercise in a hot environment. EAMC sometimes occurred for college students in swimming class, especially at the first class of the year. The purpose of this study was to determine the effect of water immersion in a swimming pool on EAMC.

#### METHODS:

Twenty-one men and 19 women (age: 18-20 years) volunteered for the study. On the testing day, the air and water temperatures were 32-33 and 27 degrees, respectively. "cramp tests", in which the occurrence of EAMC during maximal voluntary muscle contraction of toe and knee flexors at maximally shortened position for 15 s respectively, were performed before and 10 min after water immersion for 20 min. The three subjects who had EAMC during the test before the water immersion were excluded from the study. The cramp tests were performed in both leg and foot, and we counted the number of subjects who developed EAMC at least one leg or foot. Handgrip strength, standing broad jump and repetitive side jump performance were also measured.

#### RESULTS:

The numbers of subjects who experienced EAMC after water immersion were 8 in the toe flexors, and one of them also did in the knee flexors. Standing broad jump performance was significantly decreased after the water immersion (pre:  $197.0 \pm 36.3$  cm, post:  $193.2 \pm 37.3$  cm) ( $P < 0.05$ ), however, handgrip strength (pre:  $33.9 \pm 10.5$  kg, post:  $34.0 \pm 10.4$  kg) ( $P = 0.88$ ) and repetitive side jump performance (pre:  $50.3 \pm 7.9$ , post:  $50.2 \pm 9.3$ ) ( $P = 0.90$ ) did not change significantly. The changes in strength and performances did not significantly different between subjects who developed EAMC and those who did not.

#### CONCLUSION:

These results suggest that water immersion decreases the dynamic performance and increases the likelihood of EAMC.

## PREVALENCE OF NORMAL WEIGHT OBESE AMONG COLLEGE STUDENTS

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#### INTRODUCTION:

Obesity, which literally refers to excess body fat, is a growing public health problem and it is a common risk factor for many chronic diseases such as type 2 diabetes mellitus, and cardiovascular diseases [1]. On the other hand, underweight is also a growing concern for young women which is associated with malnutrition and infectious diseases. Body Mass Index (BMI) and percentage body fat (PBF) are two common screening tools for weight categories that may lead to health problems. The discrepancy between BMI and PBF has led to the identification of the normal weight obese phenotype. The current study aims to investigate the prevalence of normal weight obese and determine the specificity and sensitivity of BMI to diagnose obesity among this cohort of college students in Hong Kong.

#### METHODS:

Data were collected from Chinese students who studied in PolyU Hong Kong Community College (HKCC) between 2013 and 2017. Subject were recruited from a nutrition subject and during a series of healthy lifestyle promotion activities. Body weight, PBF and height were measured with the subject barefoot and wearing light clothing. PBF were measured by bioelectrical impedance analysis (BIA) (InBody 230, Biospace Co., Ltd, Seoul, Korea). Based on the BMI classification from the WHO and Asia-Pacific guidelines [2] and several studies that investigated the cutoffs of PBF [3-5], normal weight obese was defined as having  $BMI \geq 25.0$  kg/m<sup>2</sup> and  $PBF \geq 25\%$  for male and  $\geq 30\%$  for female. Continuous data were analyzed with independent t-test to compare between genders. Linear regression was used to determine the association between BMI and PBF. A p-value of less than 0.05 was interpreted as statistically significant.

#### RESULTS:

There were 1111 students who completed the assessments, 403 of them were male and 708 were female. The mean age, BMI and PBF of the students were  $19.4 \pm 0.9$  years,  $20.5 \pm 2.9$  kg/m<sup>2</sup>, and  $24.4\% \pm 8.5\%$  respectively. (BMI, M:  $21.1 \pm 3.0$  kg/m<sup>2</sup> vs F:  $20.2 \pm 2.8$  kg/m<sup>2</sup>; PBF, M:  $16.5 \pm 6.2\%$  vs F:  $28.8 \pm 6.0\%$ ). The association of BMI and PBF was strong and linear for male and female (M:  $r^2 = 0.54$ ; F:  $r^2 = 0.61$ ,  $p < 0.05$ ). The prevalence of normal weight obese was higher in female than male. (F:  $26.5\%$  vs M:  $2.7\%$ ). Nearly half (44.2%) of the female normal weight participants had excess adiposity problem. Few female participants (1.1%) even had the phenotype of underweight obese. The

specificity of BMI to diagnose excess adiposity was 95.8% for male and 100% for female, while the sensitivity was 48.0% for male and 14.2% for female.

#### CONCLUSION:

Our findings revealed that the high  $r^2$  of the association of BMI and PBF implied the important role of BMI in public health. However, BMI cannot distinguish the weight from fat mass and lean mass. The high prevalence of the normal weight obese phenotype among young women in this cohort explained the low sensitivity of BMI to diagnose excess adiposity. Significant amount of female may overlook their future risks for diseases. Therefore, body fat measurement should be promoted.

### CHANGES IN BODY COMPOSITION OF COLLEGE FEMALE BADMINTON PLAYERS BEFORE AND AFTER THE 3-MONTH CESSATION OF COLLECTIVE PRACTICE BY COVID-19

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#### INTRODUCTION:

Badminton is one of the popular sports enjoyed widely. In Japan, College students typically practice five to six days a week for about three hours per day. But due to the spread of covid-19, they had to stop practicing from March 28 to June 29. We are doing research aiming at the way of training to match the healthy growth and development of each player and the prevention of sports disorder through sports life. One of our initiatives is to conduct monthly condition measurements for college female badminton players. I will report on the results of that measurement.

#### METHODS:

Body composition and estimated blood hemoglobin concentration were measured as conditioning assessment. Measurements were performed in early March (March 4 and 11) and on June 30. This team was able to practice as usual until March 27. In June, a specific date was announced for the resumption of practice. Practice resumed on June 30 and measurements were taken before practice. In addition, the questionnaire was conducted on voluntary practice during the cancellation period. Statistics were conducted with a paired t-test.

#### RESULTS:

There were 17 subjects for both measurements. All players were right-handed. Body composition results showed differences in body fat percentage ( $p < 0.01$ , Mar.Jun.). Differences were also found in the results of estimated blood hemoglobin concentrations ( $p < 0.01$ , Mar.

#### CONCLUSION:

As a result, the rate of decline was greater in the upper extremity than in the lower extremity and in the right side than in the left side. In particular, the rate of decline was large on the right side of the upper. The players have been training as much as they can in difficult conditions, but the conditions have been worse than we expected. The four players who practiced were also down, but the rate of decline was not as great as the others. Many of the players had improved nutrition. Leaders and players were aware of their current state. They encouraged the players to gradually acclimate their bodies for the first month after practice resumed to prevent injuries and slowly return to their original condition.

#### ACKNOWLEDGEMENT

We appreciate all the players, instructors, and guardians who cooperated in this study. This study was supported by JSPS KAKENHI Grant Number 26350790, Senshu University research grant (2020) and Medium-term domestic researcher system.

### EFFECTS OF AN 8 WEEKS CONCURRENT TRAINING PROGRAM AMONG HOSPITAL WORKERS: PRELIMINARY RESULTS.

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#### INTRODUCTION:

Nowadays, many companies sponsor exercise programs as a strategy to improve economics and employee's health outcomes. These exercise programs have shown benefits in health, such as increases in well-being and reductions of health risk factors, and an improved work-productivity (1). The aim of this study is to determine the effects of an 8 weeks concurrent training (CT) intervention among hospital workers on physical condition variables.

#### METHODS:

10 hospital workers from Hospital Universitario Fundación Jiménez Díaz (HUFJD) (Madrid, Spain), participated in this study (age:  $42,2 \pm 10$  years; weight:  $65,4 \pm 9,1$  kg; height:  $168,6 \pm 9,2$  cm; BMI:  $23,1 \pm 3,5$  kg/m<sup>2</sup>). All participants realized a 1 session test to measure anthropometric data, cardiorespiratory fitness (CRF), functional mobility (FM) and muscular strength (MS). CRF was quantified as the maximal oxygen uptake (VO<sub>2</sub> max) estimated from the 6 Minutes Walking Test (6MWT), FM was determined with the sit-to-stand test, and MS 1RM value was estimated in lower limbs (leg press machine) and upper (bench press machine & lat pulldown machine), and divided by the subject body weight (1RM/BW)(2).

The exercise intervention consisted in 2 days a week 60-90 minutes CT sessions using cardiovascular and strength training machines.

Comparisons between pre and post training were made using a non-parametric Wilcoxon (W) test. The effect sizes (ES) were calculated using Eta squared ( $\eta^2$ ) as ( $\eta^2 = Z^2/N$ ). All variables were tested for normal distribution and means and standard deviations of the variables were calculated for descriptive statistics. The level of significance was set at 0,05.

#### RESULTS:

Eight weeks of CT among hospital workers significantly increased VO<sub>2</sub>max ( $Z = 2,60$ ;  $p = 0,005$ ;  $\eta^2 = 0,338$ ), Sit & Stand test ( $Z = 2,80$ ;  $p = 0,003$ ;  $\eta^2 = 0,392$ ), Leg Press strength ( $Z = 2,67$ ;  $p = 0,004$ ;  $\eta^2 = 0,355$ ), Bench Press strength ( $Z = 2,80$ ;  $p = 0,003$ ;  $\eta^2 = 0,393$ ) and Lat Pulldown strength ( $Z = 2,65$ ;  $p = 0,004$ ;  $\eta^2 = 0,352$ ).

#### CONCLUSION:

An implementation of a concurrent exercise program intervention among workers may have a beneficial effect in the physical condition-health related parameters, may reduce sick leave and healthcare costs to the national health systems. Moreover, increasing leisure time physical activity in adulthood is associated with lower all-cause, cardiovascular disease related and cancer related mortality (3).

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## HISTORY

## MENTORING/COACHING

### IN THE SOCIO-CULTURAL CONTEXT THE INSPIRATION OF EUROPEAN POLICIES OF SPORTS ON CHINESE POLICY-MAKING ON DUAL CAREER OF HIGH-PERFORMANCE STUDENT ATHLETES

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#### Introduction

As the economic transition of China from plan to market, China authorities had no capacity to be responsible for the lifetime of all athletes. Athletes could not compete with others in the modern society without good academic performance. In this case, university became a new start for some retired athletes and non-elite athletes. In 1986, a policy of Pilot High-performance Student Athletes (HPSA) Recruitment in Partial Universities was executed. Whereas Chinese educational authorities(CEA), to date, do not have a unified policy to support the management of HPSA. While EU guidelines on Dual Careers of Athletes(EUG) is a good reference.

#### Methods

28 physical education (PE) teachers from 14 universities which are qualified to recruit HPSA in 7 different Chinese geographical divisions took part in semi-structured cyber video interviews. Inductive analysis was applied to data analysis. Data reliability was ensured by interviewing 2 coaches from every university respectively. Interview content was verified by dual career researchers panel in Europe and China.

#### Results

Three major barriers of dual career of HPSA were concluded. Non-unified policies were made on fostering HPSA. Most of PE teachers are deficient in professional coaching and lack enthusiasm. Most of HPSA were influenced by their family values.

#### Discussion

The study showed that HPSA are in dilemma in China. Different universities implement various management policies. And the majority of them mainly take HPSA as Honor Chasers. EUG suggests adapted curriculum, e-learning and supplementary tutoring for HPSA. In this case, MOOC platform is a good option which offers different versions of courses. In addition, EUG suggests universities should have more cooperation with sports-related companies to prepare for their post-athletic life. PE teachers in China are employed after strict academic exam as full time positions. Therefore professional coaches without higher academic performance cannot work in universities as full time staffs. For this reason, most PE teachers lack advanced tactics and practical experience and can not offer efficient guidance besides extending the training time which definitely occupies HPSA more study time. Generally PE teachers have heavy teaching missions and they are unwilling to do extra training for HPSA. Thus it affected HPSA athletic performance. While EUG indicates that coaches play a crucial role and it is essential that coaches are qualified at the appropriate level. Meanwhile the thought, the Worth of Other Pursuits is Small; the Study of Book Excels Them All, has been deeply rooted in Chinese parents. Even talented children cannot engage in sports as a result. Hence HPSA normally are not good at academic work. Some universities offer scholarships to HPSA for their sports achievements only while EUG suggests that scholarships should enable HPSA combine education with their sports ambition and ensure they concentrate on their two main areas of focus.

### APPLYING CAREER GROUP COUNSELING PROGRAM FOR 20'S RETIRED ATHLETES

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#### INTRODUCTION

"Athletes encounter psychological, social and economic difficulties after sport retirement" [1]. Various support programs are implemented to help retired athletes, but there are limits to reflecting lifelong career development and individual differences [2]. Therefore, the purpose of this study is to develop and apply the career group counseling program for 20's retired athletes.

#### METHOD

First of all, we reviewed previous studies related to Adler's career counseling and then extracted the program elements. The career group counseling program consisted of six stages including introduction, self-understanding, career exploration, career decision-making, career planning and arrangement. The validity of the program was verified by the Delphi survey. Participants were recruited online and offline advertising, including program outline, anticipated benefits and risks, and confidentiality. Three female retired athletes(from Taekwondo, Badminton and Archery) participated voluntarily in this program. The average age of participants was 21.3 years(SD=1.15) and their average player experience was 11.3 years(SD=2.51). The Career group counseling was held from August 6 to August 28, 2019 at the Korea National Sport University.

The program was run once a week, 60 mins per session, for a total of 12 sessions. In order to verify the effectiveness of the program, questionnaires were career attitude maturity [3] and career decision-making self-efficacy [4] that was conducted before and after it. Result evaluation was investigated at each session. In the process, a participant who out of archery asked for withdrawal.

#### RESULT

The results of comparing the average of pre-test and post-test are as follow.

First, among the sub-factors of career attitude maturity, confidence(+.17), independence(+.20), and readiness(+.31) were higher in post-test than in pre-test. Second, among the sub-factors of career decision-making self-efficacy, self-evaluation(+.50), problem solving(+.90), future plan(+.70), goal setting(+1.00), job information(+1.00) were higher in post-test than in pre-test.

Third, retired athletes stated that they were effective in self-understanding, improving self-esteem, and expanding career route.

**CONCLUSION**

This study suggests that the career group counseling program is effective for career development of retired athletes. It will provide with practical help retired athletes need to career transition.

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**COACHING OF JAPANESE SOCCER INSTRUCTORS WITH EXPERIENCE IN EUROPE**

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**【Introduction】**

On January 1, 2005, the Japan Football Association (JFA) declared its medium- to long-term goal of becoming one of the top 10 teams in the world by 2015 (JFA 2005). For this reason, the four main pillars of strengthening the national team, youth development, training leaders, and dissemination are being strengthened, but the 2015 target was not achieved. Also, in the U-20 World Cup, which could be regarded as the culmination of the youth development era, Japan missed the main competition in four tournaments from 2009 to 2015. Under such circumstances, the country has introduced a training system such as an elite academy and training center system as in European countries, but it is necessary to delve into the coaching of the instructor who teaches on site before the system is developed.

Therefore, the purpose of this research is to conduct an interview survey with Japanese instructors who have experience in teaching in Europe, and to obtain basic materials to assist in developing a system and instructor training in Japan.

**【Methods】**

The participant was one instructor who had experience in teaching in Spain and currently teaches at the Japanese Professional League (J-League) Academy. The survey was conducted using open-ended and semi-structured in-depth interviews. The questionnaire items comprised three types: main questions, follow-up questions, and probes, based on previous study by Kitamura et al. (2005). The recorded response was transcribed and quantitatively analyzed using a text mining technique (KH Coder). In addition, we draw a network diagram (co-occurrence network) in which words with similar patterns are connected by lines, and we extracted the representative sentences based on them.

**【Results and discussion】**

As a result of performing preprocessing using KH Coder and performing simple counting of sentences, the total number of words was 9,106 words, of which 3,105 words were used in the analysis. The number of occurrences of frequent words that characterize the content was 58 for "I think" in the first place, 55 for "say" in the second place, and 48 for "soccer" in the third place. An excerpt from the co-occurrence network depicted is, "A Japanese child does what the coach says, even if he is not convinced. A Spanish child finds the meaning of training". It has long been pointed out that children at Japanese instruction sites "behave in a manner that does not detract from the mood of adults. Take an attitude that makes adults happy" (Nagano.2007). It suggests that a similar sentence is seen as an important issue for Japanese leaders and the Japanese education system. In the future, further verification will be conducted, such as increasing the number of target persons.

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**THE RELATIONSHIP BETWEEN SWIMMING ABILITY AND STUDENT'S FORMATIVE ASSESSMENT IN SWIMMING CLASS - BASED ON THE TRIAL TEACHING CLASS IN A TEACHER TRAINING COURSE-**

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**Introduction**

In Japanese school education from elementary school to high school, swimming class is the required subject in the physical education (MEXT [2008], MEXT [2008], MEXT [2009]). Therefore, swimming instruction and class management are important skills for physical education teachers. Previous studies on swimming class have evaluated based on exercise intensity and lesson plans. However, few studies have been reported that assessment of class in consideration of students swimming ability. Thus, the purpose of this study was to examine the relationship between the swimming ability of the student and the Student's formative assessment.

**Procedure of consideration**

The participants took trial teaching classes held at indoor pool in August 2019. Twenty three university students participated as the student of trial teaching class. Four of trial teaching class were the subject of this study. Instructors in each trial training classes were 4 students who belong to the physical education teacher training course. They were two or third graders who were a part of the physical education teacher training course of the university. They had experienced simulated classes more than twice. They prepared and implemented a teaching plan themselves. The target of all trial classes was for secondary school or high school students.

The swimming ability of the students was calculated based on the 25m freestyle and 200m individual medley times based on the qualification standard records of the Japan Masters Swimming Association. It was classified into swimming ability values from a maximum of 40 points to 0 points.

At the end of each class, those who had taken the trial class evaluated them using the Student's Formative Assessment Scale modified from previous research (Takahashi et.al [1994]). This scale consists of nine items and four factors, namely: outcome, motivation, ways of learning, and cooperation.

High and low groups (HG and LG) were categorized by swimming ability values. We examined the Student's Formative Assessment (SFA) of each group. As a research task, we performed t-test and Pearson's test.

**Result and Discussion**

Comparing the SFA of each group for all classes, HG showed significantly higher values than LG in 'Skill growth' ( $p < .10$ ). In the correlation between the SFA in all classes and the swimming ability, the swimming ability was strongly related to 'voluntary learning' ( $r = -0.30, p < .05$ ) and 'learning friendly' ( $r = -0.31, p < .01$ ).

There may be differences in learning and satisfaction in the class depending on the swimming ability. Therefore, it would be necessary to consider students with different swimming abilities in designing and conducting lessons.

## MOLECULAR BIOLOGY AND BIOCHEMISTRY

### THE BUILDING OF EVALUATION METHOD TO TESTING PERFORMANCE OF FOUR SPORT BIOCHEMICAL INDICATORS

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#### INTRODUCTION:

To build an evaluation method to testing the performance of four sport biochemical indicators by sigma measurement in a central laboratory.

#### METHODS:

The serum concentration of BUN(blood urea nitrogen), CK(creatine kinase), C(cortisol) and T (testosterone), selected as four-sport biochemical indicators, was tested in both IQC (internal quality control) samples and EQA(external quality assessment) samples. Firstly, the IQC samples test was performed prior to the routine test on laboratory working day. BUN & CK in two-level(low and high value, L and H) IQC samples and C & T in three-level(level 1,2 and 3) IQC samples from the manufacturers were tested on laboratory control program, totally twenty-three times. The CV%(variance coefficient) of four indicators was calculated. Secondly, EQA samples were measured in accordance with the routine unknown samples. BUN & CK in five(No.1 to 5) EQA samples and C & T in another five(No.1 to 5) EQA samples from NCCL were repeatedly tested on EQA program three times. The Bias% of four indicators were obtained from NCCL. Thirdly, the  $\sigma$ (sigma) value of four indicators was calculated on the basis of the equation:  $\sigma = (TEa\% - BiasT\%) / CVT\%$ . Particularly, the CV T% of BUN & CK was calculated according to equation  $CV\ T\% = \sqrt{((CV\ L^2 + CV\ H^2) / 2)}$ ; but that of C & T was  $CV\ T\% = \sqrt{((CV\ 1^2 + CV\ 2^2 + CV\ 3^2) / 3)}$ . The BiasT% of BUN, CK, C, and T was calculated according to equation:  $BiasT\% = (|Bias1\%| + |Bias2\%| + |Bias3\%| + |Bias4\%| + |Bias5\%|) / 5$ , and the TEa%(total allowable error) of those was checked from American CLIA'88 standard protocol.

#### RESULTS:

Among the four indicators, 1)the CVT% and BiasT% of BUN were the minima, those of C was the maximum, and those of CK & T in between, 2)the TEa% of BUN was the minimum, that of CK was the maximum, and that of C & T in between, 3) $\sigma$  value of CK was the maximum, that of T & C was separately second and third, and that of BUN was the minimum. Thus, the testing performance of CK, T, C, and BUN was separately on super excellent level, excellent level, good level and average level (but very close to a good level). To improve the testing performance, it is suggested that, 1)an appropriate sport biochemistry standardization of BUN indicator should be built, 2)the IQC samples of C indicator should be increased in quantity on the basis of improvement of calibration and maintenance of assigned instrument, 3)the IQC samples of T indicator should not be decreased in quantity.

#### CONCLUSION:

Sigma measurement method, by comprehensive analysis of standard protocol, random error(CV%) from IQC result and system error(Bias%) from EQA result, is convenient to uniformly evaluate the testing performance and make a horizontal comparison among the four indicators and a vertical comparison of the monthly data in sport biochemistry laboratory. It is recommended to promote the use of the sigma measurement method to evaluate the testing performance of sport biochemical indicators.

### EFFECTS OF EXERCISE ON ANGIOGENESIS MYOKINES EXPRESSION OF SKELETAL MUSCLE IN OBESITY RATS

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#### INTRODUCTION:

Skeletal muscle secretes various proteins, including growth factors, cytokines, and metalloproteinases, and muscle contraction during exercise training induces myogenesis by increasing the expression of myokines. Along with increased myokine expression, muscle contraction during exercise triggers neovascularization through potent angiogenic factors, such as IL-8 and VEGF. Myokine expression levels are a key indicator of immune function, and IL-8 is a major myokine that facilitates angiogenesis through C-X-C motif chemokine receptor (CXCR) 2 signaling. Therefore, the objective of this study was to analyze the effects of exercise on angiogenesis myokines expression in the skeletal muscle of high fat diet-induced obesity rats.

#### METHODS:

Male 50-week-old Sprague-Dawley rats were divided into normal diet (n=10), normal diet + exercise (n=10), high fat diet (n=10), and high fat diet + exercise groups (n=10). After 6 weeks on a high fat diet to induce obesity, a 12-week exercise program was implemented, which combined treadmill running exercise and ladder climbing exercise three times a week for 45 minutes per session. We analyzed the protein levels of interleukins (IL) 8, C-X-C motif chemokine receptor 2 (CXCR2) and vascular endothelial growth factor (VEGF) in skeletal muscles by western blotting.

#### RESULTS:

After completing the 12-week exercise program, IL-8 expression in skeletal muscle was significantly lower ( $p < .05$ ) in the HFD group than in the ND group and significantly higher ( $p < .05$ ) in the HFD+Ex group than in the ND and HFD groups. Moreover, the ND+Ex group had significantly higher ( $p < .05$ ) IL-8 expression than the ND group. CXCR2 expression was significantly lower ( $p < .05$ ) in the HFD group than in the ND group, and after 12 weeks of exercise training, the HFD+Ex group displayed significantly higher ( $p < .05$ ) CXCR2 expression than the HFD group. VEGF expression was significantly lower ( $p < .05$ ) in the ND+Ex and HFD groups compared to the ND group, but after 12 weeks of exercise training, the HFD+Ex group showed significantly higher ( $p < .05$ ) VEGF expression than the HFD group.

#### CONCLUSION:

This study demonstrates that an exercise program combining aerobic and resistance exercise activates the expression of several myokines, including IL-8, CXCR2, and VEGF, in the skeletal muscle of aging obese rats. IL-8 activates capillary tissues and the proliferation of vascular

endothelial cells. In particular, it is a key angiogenesis-facilitating myokine that signals through CXCR2, which has been suggested to play an important role in the formation of skeletal muscle blood vessels. It has been widely reported that the expression level of VEGF, an important angiogenic factor, is activated by acute exercise. In conclusion, obesity resulted in decreased myokines in the skeletal muscles of aging rats, but exercise training increased myokines secretion, suggesting its promise in reducing inflammation and enhancing immune function during obesity.

### EFFECTS OF THE ACTN3 R577X GENOTYPE ON THE RESPIRATORY AND SKELETAL MUSCULAR STRENGTH IN COLLEGE ATHLETES

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#### INTRODUCTION:

One of the main genetic factors that influence the generation of muscular strength and power is the gene that encodes the structural protein  $\alpha$ -actinin-3 (ACTN3). The R577X polymorphism (rs1815739) of ACTN3 has been associated with indicators of muscle and physical performance in athletes and general population in many studies, but not in all. Thus, the aim of the present study was to describe the effect of the ACTN3 R577X genotype on the respiratory and skeletal muscular strength in college athletes.

#### METHODS:

129 unrelated Chilean college athletes who practice athletics, weightlifting, handball, volleyball, rugby, basketball, soccer or futsal were volunteered for the study. Respiratory muscle strength was assessed by maximal inspiratory pressure (MIP). Skeletal muscle strength was measured by 1RM maximal voluntary isometric handgrip strength. Moreover, vertical jump height and power were measured with squat jump (SJ). Blood samples were collected for molecular analysis, and genotyping was completed by conventional polymerase chain reaction and restriction fragment length polymorphism (PCR-RFLP). An additive model was used for the genetic analysis.

#### RESULTS:

Genotypes distribution was RR: 34,8% (n=45), RX: 50,4% (n=65), XX: 14,7% (n=19). The relative frequency of alleles was R: 0,601 and X: 0,399. There were differences in the MIP between RR and XX genotypes (102,2 $\pm$ 25,4 vs. 121 $\pm$ 21,8 cmH<sub>2</sub>O; p=0,02), 1RM in handgrip strength test in dominant arm between RR and XX genotypes (37,8 [25,4-59] vs. 49 [33,5-64,1] kg; p=0,015), vertical jump height (SJ) between RR and XX genotypes (21,1 [11-44,1] vs. 29,4 [14,2-42,7] cm; p=0,0006) and between RX and XX genotypes (23,7 [11-41,2] vs. 29,4 [14,2-42,7] cm; p=0,002), vertical jump power (SJ) between RR and XX genotypes (2407,3 [112,5-11908,3] vs. 3265,2 [1840,4-4171,2] W; p=0,01) and between RX and XX genotypes (2645,4 [1062,6-4873,1] vs. 3265,2 [1840,4-4171,2] W; p=0,02). There were no differences in age or type of sports between genotypes.

#### CONCLUSION:

The results found in this study show in a remarkable way that the subjects of the XX genotype have greater respiratory muscle strength. In our knowledge, this is the first time that this difference in respiratory muscle strength has been reported according to different genotypes of the R577X polymorphism of ACTN3. In relation to skeletal muscle strength, the results of this study are opposed to most of those reported in the literature, showing higher handgrip strength, vertical jump height and power in subjects of genotype RR. These results suggest that, the R577X polymorphism of ACTN3 influences skeletal and respiratory muscle performance in college athletes. Finally, new research is needed for exploring these differences between ACTN3 R577X genotypes at the maximal inspiratory pressure, handgrip strength, vertical jump height and power in other populations.

### EFFECT OF LONG-TERM TREADMILL EXERCISE ON BASOPHIL MEDIATED TH2 IMMUNOREGULATION IN MICE

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#### INTRODUCTION:

Hormones, neurotransmitters and cytokines secreted into the blood during exercise, and the newly reported bioactive substances such as myokines and adipokines secreted from skeletal muscle and adipocytes have various effects on immune function. In addition, it is thought that immune function is regulated in an integrated and coordinated manner by the interaction between immunocompetent cells affected by these humoral factors. However, the molecular mechanisms of exercise mediated immunoregulation and whether exercise has a positive or negative effect on allergic or inflammatory responses remains unclear. To address these issues, we have recently focused on basophils, which play an important role as initiator cells and antigen presenting cells in the early stage of Th2 immune response, as well as effector cells during allergic reactions and parasitic infections. We found that basophils change the mechanism of cytokine production in response to their activation status and affect the subsequent immune response. In this study, we focused on the regulation of Th2 immune response by basophils and aimed to elucidate the molecular mechanism of immunoregulation by exercise.

#### METHODS:

In order to investigate the effect of exercise on basophils, C57BL/6Njcl wild-type mice were subjected to treadmill running for several weeks (60 min/day, 5 days/week, average speed 10 m/min), and the appropriate exercise period was examined. At the same time, blood samples were collected before, during and after the exercise period, and the changes in blood cytokines due to exercise were examined. After the end of the exercise period, bone marrow and spleen cells were isolated and analyzed by flow cytometry.

#### RESULTS:

The proportion of bone marrow basophils (FceRIa+,c-kit-,DX5+) in the exercise group was significantly lower than that in the non-exercise group by treadmill running for 6 weeks (p <0.05). On the other hand, similar changes were not observed in spleen basophils. Next, the changes in the blood cytokine levels during exercise were examined. After the exercise period, a decrease in IL-1 $\alpha$  concentration and an increase in IL-12p40 and IL12p70 concentrations were observed. However, no changes were observed in IL-3, GM-CSF and TSLP after the period. These results supported the fluctuation of inflammatory cytokines caused by exercise reported in the previous study. However, there were no significant changes in cytokines, such as IL-3, GM-CSF and TSLP, which have been reported to affect the basophil activation and differentiation.

#### CONCLUSION:

Therefore, it was suggested that long-term continuous exercise may have a local effect on the differentiation and proliferation of murine basophils with systemic fluctuation of humoral factors.



## GENE POLYMORPHISMS AND ITS CONNECTIONS WITH MOTIVATION AND THRILL SEEKING AMONG ATHLETES OF VARIOUS SPORT DISCIPLINES

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### INTRODUCTION:

One of the areas that are considered in relation to gene polymorphisms is the influence of dopamine as hormone of "motivation, thrill and adventure seeking". Its impact can be treated as a key element of sport performance. That's why we consider as important the association between polymorphisms and personality traits connected with motivation. There exists direct evidence for association of dopaminergic mechanisms and many features important for sport achievements, among them personality traits or temper, that is treated as a set of individual emotional reactions and skills connected with stimulus from surrounding environment.

### METHODS:

In our project we analyzed several polymorphisms (rs1076560, rs1800498, rs12364283, rs1799732, rs1079597, rs6276, rs1800497) that showed the relation with personality traits among athletes of martial arts and extreme sports, such as judo, boxing, karate and MMA. The research group included 300 sportsmen who trained for at least 8 years. The study excluded people who took psychiatric medication. All the athletes underwent a psychological test using Temperament and Character Inventory (TCI) and Giessne Test Tool (GTT). We also collected biological material to isolate DNA for further analyses of polymorphisms in selected genes of the dopaminergic system. rtPCR method was applied to determine polymorphisms in chosen genes.

### RESULTS:

We observed an association between the phenotype of a predisposition towards sport and genetic factors due to different heredity of the dopaminergic system functioning. It also should be noticed that different alleles are connected with different intensity of specific features, measured with TCI test. We observed higher scores on the scale of Openness, Extraversion and Conscientiousness and lower on Neuroticism and Agreeability. Overall, the results indicate that there is an association between different polymorphism occurring in analyzed population and motivation and thrill seeking in the population

### CONCLUSION:

There is a relation between personality traits and polymorphisms in genes connected with dopaminergic system. The observed association seem to be important in relation to motivation in goal achieving in sport. In also can be of a high importance in public health in general, medicine and other academic fields, including economics.

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## GENETIC ASSOCIATION RESEARCH IN FOOTBALL: A SYSTEMATIC REVIEW

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### INTRODUCTION:

Genetic variation is responsible for a large amount of the inter-individual performance disparities seen in sport. As such, in the last ten years genetic association studies have become more common; with one of the most frequently researched sports being football. However, the progress and methodological rigour of genetic association research in football is yet to be evaluated. Therefore, the aim of this study was to identify and evaluate all genetic association studies involving football players and outline where and how future research should be directed.

### METHODS:

This review was conducted in accordance to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. A systematic search was conducted in the Pubmed and SPORTDiscus databases using the Boolean search of: (((football OR soccer)) AND ((gene) OR (genetics) OR (polymorphism) OR (genotype) OR (snp) OR (phenotype))). To be included in the review, studies had to be: (a) genetic association studies, (b) published in English, and (c) include football players.

### RESULTS:

Eighty studies were identified which met the pre-defined inclusion criteria, of which 55% have been published within the last four years. Sixty-six studies used a candidate gene approach. The focus of the studies included: Injury (n = 22), Athletic Status (n=20), Physiological Phenotype (n=20), Epigenetic (n = 7), Health (n = 5), Psychological (n = 3), Bone-Phenotype (n = 2), and Career Progression (n = 1). Fifty studies included only footballers, whilst the remaining 30 combined footballers with athletes of other sports. Twenty-two studies analysed footballers of different ethnicities together, whilst 22 others failed to report ethnicity. In addition, only five studies included information regarding on-field positions. Finally, 103 distinct genes have been investigated, of which, actinin alpha 3 (ACTN3; n = 27) and angiotensin I converting enzyme (ACE; n = 25) are the most frequently studied.

### CONCLUSION:

Studies have increased at a substantial rate and significant progress has been made with regards to study type and genes investigated. However, research has predominately focused on the association of the ACTN3 or ACE gene. In addition, there are several methodological inconsistencies which hinder research implications, such as; inadequate description or omission of ethnicity and on-field positions. Furthermore, there is a limited amount of research on several key areas crucial to footballing performance, in particular; psychological related traits. Moving forward, improved research designs, larger sample sizes, and the utilisation of genome-wide and polygenic profiling approaches are recommended. Finally, we introduce the Football Gene Project, which aims to address several of these limitations and ultimately facilitate greater individualised athlete development within football.

## MOTOR LEARNING AND MOTOR CONTROL

### EFFECT OF AGE ON THE POSTURAL STABILITY IN THE MEDIAL-LATERAL DIRECTION DURING OBSTACLE-CROSSING

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#### INTRODUCTION:

A decline in the capability to avoid obstacles with age may be implicated in the higher incidence of falls among the older adults. Especially, maintenance of the body's balance under attentional demands is essential for successful obstacle-crossing. However, few studies have focused on age-related changes in the postural stability in the medial-lateral direction during obstacle-crossing in response selection tasks. This study aimed to investigate the effects of age on medial-lateral stability during obstacle-crossing.

#### METHODS:

The subjects comprised 29 community-dwelling older women and 10 young women. The subjects were instructed to step over a 10 cm high obstacle as quickly as possible after a visual cue of blue light, and to continue walking for several steps. The obstacle was placed at 20% of subject's height in front of the subject. The measurements were performed under two conditions; simple reaction (single-task) and choice reaction (selection-task) trials. Only a blue light was illuminated during single-task trials, whereas blue, red, and yellow lights were illuminated randomly during selection-task trials. The subjects were instructed to step over the obstacles as fast as possible when the blue light was illuminated, and to continue standing when the red or yellow light was illuminated. The medial-lateral stability during single-support phase of leading limb (i.e. limb crossing the obstacle first) was evaluated. The medial-lateral stability was defined as the medial-lateral distance between the whole body's center of mass (COM) and the center of pressure (COP) of the stance foot. The landing distance of the leading foot in front of the obstacle was also assessed as an index of obstacle negotiation strategy.

#### RESULTS:

With respect to age-related differences, the distance between the COM and COP of the older adults was significantly greater than that of the young adults in the single-task trial, whereas the age-related differences were not observed in the selection-task trial. The landing distance of the leading foot of the older adults was significantly lesser than that of the young adults, in both the single-task and selection-task trials. When comparing the differences between the single-task and selection-task trials in older adults, there was no significant difference in the distance between the COM and COP, while the landing distance of the leading foot decreased when stepping over obstacles during the selection-task trial, compared to that during the single-task trial.

#### CONCLUSION:

Our findings showed that older adults can adopt shorter-step strategies when stepping over obstacles during the response selection task, and that there was no age-related effect on the medial-lateral distance between the COM and COP under the selection-task condition. These results suggest that postural stability in the medial-lateral direction when crossing obstacles may be maintained through the adjustments of the step length in older adults.

### THE INFLUENCE OF CHILDCARE ENVIRONMENT ON ENGAGEMENT IN VARIOUS BODY MOVEMENTS DURING PLAY ACTIVITIES

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#### INTRODUCTION:

The performance of fundamental motor patterns during early childhood—when the nervous system develops rapidly—is an important factor in the acquisition and improvement of various common movements and the enhancement of various aspects of physical strength. Play enables young children to engage in a greater frequency of such movements. Therefore, the aim of this study was to investigate children's physical movements during play activities, as well as the features of childcare environments that elicit such movements during play among preschoolers.

#### METHODS:

Participatory observation was performed the play of four- and five-year-old preschool students was observed through participatory observation and both video and written records were made. From the obtained records, two activities in which children engaged were analyzed: lion play (Scene 1), and super hero play (Scene 2). The movements recorded in these scenes were analyzed based on five aspects: (1) type of movement according to Yoshida's (2005) "42 basic movements", (2) involvement of preschool teachers, (3) relationships with friends, (4) objects and locations used for play, and (5) theme of play.

#### RESULTS:

Number of movements observed in Scenes 1 and 2 were 5 and 14, respectively. The disparity in number of movements between the two scenes was considered a function of the "second-person involvement" of preschool teachers who tried to empathize with the children.

#### CONCLUSION:

Overall, the results suggest that the various movements displayed by children were derived from the interaction of friends, objects, places, and stories—based on the second-person involvement of preschool teachers who tried to understand and sympathize with the children's feelings. These results further suggest that preschool teachers must understand and empathize with preschool children's play to promote engagement in a greater number of basic motor patterns.

#### References

Yoshida I (2005) *Journal of health* 55 (7): 507-511

Saeki Y (2017) *Education as caring about the world children care – A second-person approach to early childhood care and education*. Minerva Publishing.

### INTERPERSONAL MOVEMENT SYNCHRONIZATION DURING FAST CONTINUOUS TAPPING TASK IN COMPETITION

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#### INTRODUCTION:

An analysis of the 2009 Men's 100m Sprint Final reported that the phenomenal world record that was set there involved unintended interpersonal synchronization between the first and second-place sprinters (1). In contrast, reanalysis have reported no evidence to support interpersonal synchronization (2). On the other hand, it was also suggested that interpersonal synchronization was theoretically applicable. This suggests that interpersonal synchronization during competition can change the movement of athletes and explain performance fluctuations due to competition. Therefore, it is necessary to rigorously examine whether synchronization occurs during competition. In this study, we examine synchronization between two competing subjects using Fitts's continuous tapping task, which involves a periodic movement of the arm in an experimental environment. When synchronization did occur, we also considered the synchronization pattern. We adopted Fitts's task because of its advantage of allowing strictly unified task difficulty.

#### METHODS:

There were 16 subjects in the study. The task difficulty ID was determined from the target width and the distance between targets. The 15-second trial was performed twice, under individual and competitive conditions. For all trials, the coordinates of the stylus tip were obtained at 245 Hz using the Motion Capture System. Movement time (MT) was calculated for each trial as the average time per tap, and average values were determined for each condition. In the competitive condition, the relative phase was calculated from the coordinate data of the two stylus tips using the Hilbert transform. In-phase synchronization (subjects proceed simultaneously in the same direction) is defined as a relative phase from 0 to 1 rad, and anti-phase synchronization (subjects proceed simultaneously in opposite direction) as a relative phase from  $\pi-1$  to  $\pi$  rad. Other values are defined as asynchronous.

#### RESULTS:

In the relative phase analysis, we observed both in-phase and anti-phase synchronization. Furthermore, the MT was significantly shorter by 40ms under competitive conditions ( $p = 0.011$ ), suggesting that the taps of both subjects quickened during competition. We found that participants' performance could be classified into three groups based on relative phase histograms and time series change patterns. The first group consists of trials in which the proportion of in-phase synchronization exceeded 80%; the second group, trials in which both in-phase and anti-phase synchronization exceeded 40%; and the third group, trials in which the three types of synchronization occurred in equal proportions.

#### CONCLUSION:

We confirmed that synchronization occurred when subjects competed using a simple tap task. Furthermore, we classified their movement into three synchronization patterns.

#### REFERENCES:

- 1) Varlet & Richardson, JEP:HPP. 2015
- 2) Blinkslager & De Poel, JEP:HPP. 2017

## DIFFERENCE BETWEEN INTENTIONAL AND REACTIVE MOVEMENT IN SIDE-STEPS: A TEMPORAL STRUCTURE OF "BOHR'S LAW"

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#### INTRODUCTION:

There is asymmetry in the execution time (MT) between intentional movement and reactive movement. Previous studies have reported that reactive movements are faster than intentional movements (known as "Bohr's law"); however, these results were obtained only for hand-reaching tasks, such as pressing buttons or throwing a karate punch. No studies of whole-body movement with movement of the center of mass (CoM) have been conducted. This movement has many degrees of freedom because it involves many joints, and it requires greater force than hand-reaching movements because the whole body has a larger mass than only the upper limbs. Herein, we determined the differences in the patterns of time generation and force exertion to elucidate the mechanism of "Bohr's law" in whole-body movement with the CoM.

#### METHODS:

Ten participants performed a side-stepping task, which requires at least two steps, based on the following two conditions: (i) an intentional movement condition (IMC), wherein the movement was initiated at the participants' own timing, and (ii) a reactive movement condition (RMC), wherein the movement was initiated the moment a light-emitting diode bulb in front of the participants lit up. We collected the data on the ground reaction forces (GRFs) using two force plates and body coordinates. The onset time of movement was calculated based on the GRFs with the onset earlier than those of velocity and position.

#### RESULTS:

The MT was significantly shorter in the RMC than in the IMC ( $p < 0.001$ ). For lateral peak velocity, the IMC was significantly greater than the RMC ( $p < 0.001$ ). Furthermore, the difference in time to lateral peak velocity exceeded the difference in MT, and this trend was confirmed for all participants. Specifically, the mean of the time difference in MT was 57 ms, and the mean of the time difference in time to peak velocity was 84 ms. This result suggests that the velocity of reactive movement reverses the velocity of intentional movement during the movement.

#### CONCLUSION:

We confirmed that "Bohr's law" was applicable in hand-reaching tasks and in whole-body movement with the CoM. We calculated the onset time based on the GRFs instead of the displacement of body coordinates, and this new method indicates that counting of MT is initiated before displacement of the body coordinates is initiated. The confirmation of "Bohr's law" in this method provides strong support for the hypothesis that these two movements have different neural bases. Moreover, we identified three phases, including the velocity reversal phenomenon associated with the produced mechanism of "Bohr's law," and provided the temporal structure. It is considered that the difference in the pattern of force exertion accompanying the two styles of motor planning with different accuracies was strongly associated with this motor characteristic. These findings may serve as important basic data to scientifically clarify the mechanism of complex physical tactics implemented in 1-on-1 dueling in various sports.

## ARTIFICIAL CO2-WATER LOWER LEGS BATHING AFFECTED QUIET STANDING POSTURE CONTROL

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#### INTRODUCTION:

The effects on autonomic nervous system of local water immersion at neutral temperature might also influence the standing posture control. In this study we evaluated the effects on COP fluctuation in human subjects of the standing position of lower leg-bathing prior to start. Additionally, influence of bath-water CO<sub>2</sub> was investigated.

#### METHODS:

The healthy female college students (n=12) participated in this study. Postural sway was recorded by detecting the body's center of gravity continuously with a force platform equipped with a data processor. Subjects were requested to stand on the platform with their feet parallel, gazing at a target, a black circle with a diameter of 10cm on a white background, fixed at a 2.0m distance and at the height of each subject's eyes. The body sway of each subject was recorded for 1min, first with the eyes open (EO) and next with eyes closed (EC). During each task, the foot center of pressure (COP) position and horizontal ground reaction force were measured. The path length of COP and area of body sway were registered. Posture sway was recorded pre and post lower legs bathing. The subject was then immersed up to the tibial point for 10 min in tap-water at a thermoneutral temperature of 35°C. The electrocardiogram (ECG) was recorded continuously using a multitelemeter system. Cutaneous blood flow (BF) was measured on the index finger and on the right calf by laser-Doppler flowmetry. The index finger was not immersed, whereas the right calf site was immersed. Statistical evaluation of the data was done by paired student's t-test. Significance level was set at the  $p < 0.05$ .

#### RESULTS:

The path length was significantly decreased by lower legs water immersion in both EO and EC conditions. However, there was no significant difference between the tap-water and the CO<sub>2</sub>-water. Biomechanical study indicated that anterior–posterior balance is predominantly under ankle control, whereas medial–lateral balance is under hip control [1]. Furthermore, body sway was stabilized by somatosensory input from the ankles and feet. Therefore, it is considered that somatosensory input to control those muscles might be modified by lower legs bathing at thermoneutral temperature. These results suggest that bathing, even in local body part immersion, possibly improve human posture control.

#### CONCLUSION:

In the present study, we showed that local water immersion at neutral temperature is able to contribute to a more stable standing posture. We hypothesized that this effect of water immersion might be due to somatosensory modification by the local immersion.

[1] Winter DA, et. al. Unified theory regarding A/P and M/L balance in quiet stance. *J Neurophysiol* 75:1-10. 1996.

### MOTOR RELATED CORTICAL POTENTIAL INDUCED BY IVE RESPONSE TO BADMINTON VIDEO CLIP

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#### INTRODUCTION:

Event related potentials (ERPs) are used to analyze human mental activity during sports as well as daily life. Motor related cortical potential (MRCP) is one of the ERPs and appears just before the muscle activity. To measure MRCP, it is necessary to average electroencephalography (EEG) because this potential is very small electrical activity. For averaging of EEG, the same situation should be repeated. But the same situation never happens in badminton. So we used video clips of badminton to measure MRCP.

In badminton, player should respond to various flights. Previously, we measured MRCP when the participant responded to the clear video clip. This measurement was also done for the drop video clip and the smash video clip. The amplitude tended to be larger when the participant responded to smash video clip. In badminton match, the opponent deliver various flight randomly. Therefore, we measured MRCP when the clear, drop and smash video clips were randomly presented to the participant in this study.

#### METHODS:

Badminton video clips were made for the experiment. In the video clip, the player on the right side delivered long high service to the left side player. The left side player delivered smash, drop or clear randomly. Then the right side player hit the shuttlecock. The participants were asked to push the button at the time the right side player hit finally the shuttlecock. EEG was recorded from 12 electrodes including C3, Cz, C4 according to the international 10-20 method. 45 shots for each flight was randomly appeared in the video clip. Averaging was done for each flight. Electrooculogram was also recorded to detect artifact and averaging was done for the trials without artifact. Electrical signal at the pushing button was used for the trigger of the averaging.

#### RESULTS:

Cz was the location where the largest amplitude of MRCP was obtained in this study. This was in accordance with previous studies and suggests that Cz was most active location. All participants responded with right thumb and amplitude from C3 was larger than the one from C4. This reflects that activation of primary motor cortex for the right thumb. Early component of MRCP is called readiness potential. In this study, we obtained the different shape of readiness potential compared with previous studies. For the smash task, readiness potential grew monotonically, for the drop and the clear task, it increased biphasically.

#### CONCLUSION:

It seemed that the difference of time pressure among the flights caused the different shape of readiness potential, early component of MRCP

### INCREASED INTERMUSCULAR COHERENCE NEGATIVELY IMPACTS FORCE STEADINESS IN THE PRONATED FOREARM POSITION DURING ELBOW FLEXION

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#### INTRODUCTION:

The coordinated activity between muscles allows for force modulation (Charissou et al, 2016). We previously suggested that differences in force steadiness (FS) between pronated (PRO), supinated (SUP), and neutral (NEU) forearm positions was due to reduced spinal or cortical excitability (Yacyshyn et al, 2020). Shared spinal and cortical inputs between two muscles may be achieved through the quantification of intermuscular coherence (IMC); that is the spectral correlation between two EMG signals. The aim of this study was to evaluate IMC between agonist muscle pairs to determine cortical and spinal contribution to position dependent differences in FS.

#### METHODS:

Ten right hand dominant males (22.6 ± 2.9 yrs) performed elbow flexion isometric submaximal tracking tasks at 10% of MVC in PRO, SUP and NEU orientations, and FS was calculated as coefficient of variation of force. The root mean square was used to measure the amplitude

of EMG for the short head (SH), long head of the biceps brachii (LH), and the brachioradialis (BR). IMC was determined between these muscles in the alpha ( $\alpha$ ; 8-12Hz) and beta ( $\beta$ ; 13-30Hz) frequency bands across forearm positions.

#### RESULTS:

The coefficient of variation of force was highest in PRO ( $1.9 \pm 0.7\%$ ) compared to NEU ( $1.5 \pm 0.2\%$ ) ( $p=0.03$ ) and SUP ( $1.6 \pm 0.3\%$ ) ( $p=0.03$ ) positions. No difference was observed in EMG amplitude between positions. The IMC in the  $\beta$  frequency band for the SH-BR in the PRO position was higher ( $0.30 \pm 0.08$  AU) compared to SUP ( $0.25 \pm 0.05$  AU) ( $p=0.036$ ) and NEU ( $0.24 \pm 0.03$  AU) ( $p=0.03$ ) positions. Similarly, IMC $\beta$  for the LH-BR in the PRO position was higher ( $0.32 \pm 0.06$  AU) when compared to the SUP ( $0.25 \pm 0.06$  AU) ( $p=0.015$ ) and NEU ( $0.25 \pm 0.04$  AU) ( $p=0.023$ ) positions. There was no effect of position in the IMC $\alpha$ .

#### CONCLUSION:

Increased IMC $\beta$  in the SH-BR and LH-BR pairings were observed in PRO compared to NEU and SUP. The position dependent differences in IMC $\beta$  suggests that the shared supraspinal input to muscles is contributing to position dependent differences in FS. The lack of results on IMC $\alpha$  suggests that spinal inputs have little influence on muscle coordination and position dependent differences in FS. This study suggested that increased coherence of agonist muscles arising from supraspinal input likely contributes to PRO being less steady than NEU and SUP forearm positions.

## MOTOR LEARNING TO RIDE A SELF-BALANCING SCOOTER: A SURFACE ELECTROMYOGRAPHY STUDY

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#### INTRODUCTION:

A self-balancing scooter (SBS), a personal mobility device, is easy to ride even with little practice. Riders must control their centre of pressure during standing on the unstable board. As learning to ride an SBS progresses quickly, it is suitable for studying the motor learning of balance control. This study aimed to elucidate the process from a neuroscience perspective by using surface electromyography (EMG) signals and demonstrate the rapid decrease in EMG amplitude in the lower limbs and reorganization into an efficient muscle activity pattern during learning to ride the SBS.

#### METHODS:

Twelve healthy men who had no experience with riding any SBS participated in this study. They were required to ride an SBS at a distance of 6 m forward and backward continuously in 5 cycles. We measured the execution time spent on each moving section. Surface EMG signals during SBS riding were recorded from the bilateral tibialis anterior (TA), soleus (SOL), and gastrocnemius (GAS), and right rectus and biceps femoris. For comparison, EMG signals were also recorded during quiet standing (QS) on the floor. EMG measurements were standardized by the premeasured maximum voluntary contraction (MVC). The integrated EMG (iEMG) of each muscle during SBS riding and QS was calculated and analysed.

#### RESULTS:

The execution time was significantly shorter in the fifth than in the first trial (forward:  $5.5 \pm 1.3$  vs.  $3.3 \pm 1.3$  sec,  $p=0.029$ ; backward:  $11.6 \pm 3.1$  vs.  $4.3 \pm 1.5$  sec,  $p<0.001$ ). With the shortening of the execution time, the EMG parameter values of the lower limbs decreased. For example, the iEMG of the right TA during the fifth forward movement was approximately one-seventh of the first ( $14 \pm 8$  vs.  $2 \pm 2$  %MVC,  $p=0.002$ ). The iEMG of the right SOL and GAS also showed a tendency of decrement, but no significant differences were found between the fifth and first (SOL:  $26 \pm 19$  vs.  $13 \pm 5$  %MVC,  $p=0.162$ ; GAS:  $35 \pm 22$  vs.  $17 \pm 11$  %MVC,  $p=0.054$ ). As compared with QS, the right TA and SOL showed no significant difference in iEMG during the fifth forward movements (TA:  $2 \pm 2$  [fifth] vs.  $1 \pm 0$  %MVC [QS],  $p=0.910$ ; SOL:  $13 \pm 5$  [fifth] vs.  $8 \pm 2$  %MVC [QS],  $p=0.233$ ). We analysed the co-contraction index (CI) of the iEMG of the SOL and TA ( $TA/[TA+SOL] \times 100$ ). We found a significantly greater CI during the first forward movement than during QS ( $34 \pm 11$  [first] vs.  $9 \pm 3$  % [QS],  $p<0.001$ ), but the difference between the fifth and QS was not significant ( $13 \pm 8$  [fifth] vs.  $9 \pm 3$  % [QS],  $p=0.772$ ).

#### CONCLUSION:

These results showed a rapid neurological motor learning process in learning to ride the SBS. At the first movement, we found a strong TA activity and large CI, which suggest the strategy to fix the ankle joint in an unstable and unfamiliar environment. After only 5 cycles, the TA activity and CI decreased to the same level as QS, which suggests that the subjects acquired efficient muscle activity pattern. These processes can be explained by the theory of freezing-freeing of the degrees of freedom during skill acquisition (Bernstein, 1967).

## NEUROMUSCULAR PHYSIOLOGY

### EFFECT OF ELECTRICAL STIMULATION ON BONE STRUCTURES IN HIND-LIMB-SUSPENDED RATS : A NEW ATTEMPT OF USING NON-CONTACT ELECTRICAL STIMULATION BY VECTOR POTENTIALS

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#### INTRODUCTION:

It had been known that an aging and an inactivity decreased a bone mass and then caused an osteoporosis. On the other hand, it was reported that an acupuncture and a transcutaneous electrical stimulation showed an inhibition of the bone resorption and a promotion of the bone formation, from a study using a hind-limb suspension that caused a decrease in a mechanical stress to the hind-limb of rat. However, an extension that effect of the electrical stimulation was expected was limited near the portion that an electrode was attached. Recently, a vector potential (VP) generator was developed. It was expected that the electrical stimulation with an apparatus could spread in the wider extent than the transcutaneous electrical stimulation that used the electrode because an electricity flowed in the whole in the apparatus. However, the effect hasn't been tested actually. Therefore, a purpose of this study was to investigate the effect of the non-contact electrical stimulation on the bone structures in the hind-limb suspended rats.

#### METHODS:

Thirteen-six male rats (wistar strain, 7-week-old) were used for materials and were divided into an experiment groups (EX) and control (CO). Moreover, EX was subdivided into 15(V15), 30(V30), 60(V60), 90(V90) and 120(V120) minutes groups from the point of view of differences of the times that each rat was stimulated. In EX, a tail was suspended in the cage for three weeks the non-contact electrical stimula-

tion gave to their whole body in the VP generator under the anesthesia for 15, 30, 60, 90 or 120 minutes/day, 5days/week, for 3 weeks. After the experimental period, femurs of each group were excised after an euthanized and they were analyzed morphometrically.

**RESULTS:**

As to a cortical bone, remarkable bone resorption was recognized in HS, V15 and V30, their cortical bones were thin compared to CO. On the other hand, a bone resorption was inhibited in the groups that the stimulating times were more than 60 minutes. Concerned to a cancellous bone of metaphysis, widths in the directions of superior and inferior were narrow in HS, V15 and V30 compared to CO, but, similar to the cortical bone, were maintained in the groups that the stimulating times were more than 60 minutes.

**CONCLUSION:**

It was suggested that the decrease in the bone mass caused by the hind-limb suspension could be inhibited with the non-contact electrical stimulation for at least 60minutes.

**NORMALIZATION OF SEMG SIGNAL DURING GAIT GROUNDED ON BASELINE**

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**INTRODUCTION:**

Surface electromyography (sEMG) is a technique concerned the recording and analysis of myoelectric signals. It could be used for medical research, ergonomics, rehabilitation and sport science. Surface electromyography is the most used technique to acquire muscle signals in motion studies because it is not invasive. However, it has many limitations. First of all its repeatability. Electrodes are positioned on the skin of the person by an operator and it could be different time to time, also on the same person. The last, but not the less important, limitation of sEMG is normalization. The time parameters are normalized regarding the duration of the task, the problem is the normalization regarding the amplitude of the signals. MVIC (Maximum Voluntary Isometric Contraction) is a technique to calculate the highest value of force of that specific muscle. It is done performing the maximum contraction against a static resistance or against the resistance of an operator (MMT – Manual Muscle Test). The signals are used as the 100%, so the signal recorded during the task will be a percentage of it. These normalization method is the most used but, as shown in many books and texts, for example in Perry (2010), there is a huge difference between different samples carrying out the same task.

The aim of this study is to use the baseline of sEMG signal as the 0% and normalize the amplitude of the signals using multiples of that.

**METHODS:**

Two people composing the sample (29 yrs, 178.5 cm, 76 Kg). The skin of the people has been cleaned with alcohol and treated with a conductive gel. During every acquisition have been made the MVIC test to the subjects and recorded the baseline of tibialis anterior of predominant leg while standing. Has been used an electromyograph with an acquisition frequency of 1000 Hz (BTS FREEEMG). A IMU (BTS G-Walk) has been used to normalize the time parameter of the gait. The subjects performed several gaits each in different days. To analyze the signals has been used BTS Smart software pack. First step has been the RMS of all the signals, without any additional filtering because of the quality of the signals and they have been time normalized thanks to the IMU. Baseline has been calculated as the mean of the signal during 10 seconds standing, while the MVIC value is the peak of the signal during the test. For statistical analysis have been calculated two way ANOVA ( $p < 0,05$ ), ICC (Intraclass Correlation Coefficient) and SEM (Standard Error of the Mean). These indexes are the suitable ones to understand the reliability of the measures and compare them to each other.

**RESULTS:**

Subject 1 ICCs (0.28 0.3 0.29 0.36 baseline and 0.4 0.54 0.52 0.41 MVC), Subject 2 ICCs (0.33 0.35 0.38 0.42 baseline and 0.27 0.29 0.3 0.34 MVC)

**CONCLUSION:**

The subject 1 has lower ICC values for baseline, it means the MVC normalization is better. But the subject 2 has higher ICC values for baseline than the MVC. We need for more people composing the sample to verify which technique is better.

**NEUROMUSCULAR ADAPTATIONS AFTER A 3 WEEKS MAXIMAL STRENGTH TRAINING**

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**INTRODUCTION:**

Maximal Strength Trainings (MST) are efficient trainings to quickly develop strength production. The modulation of agonist and antagonist muscle activations is crucial for the increase and stability of strength production. Recent studies revealed that muscle activations are altered after intensive training (1). These authors also highlighted that training induced an increase of the magnitude of corticomuscular coherence (CMC) reflecting the commands sent by the motor cortex to the muscles (2). Interestingly, these adaptations the motor commands can be seen after few days of motor training (3). This study aimed to evaluate the neuromuscular adaptations induced by MST by investigating the modulation of muscle activations and CMC.

**METHODS:**

13 participants performed 9 training sessions over 3 weeks. The training consisted of 4 sets of 4 isometric plantarflexion contractions at  $90 \pm 5\%$  of the daily maximal voluntary contraction (MVC) performed on a dynamometer. Evaluation sessions were performed prior to (PRE) and at the end (POST) of the MST. Each evaluation session consisted of 3 sets of 20 isometric PFs. The level of contraction was randomly assigned to 20% of the initial MVIC (T0; PRE) and 20% of the daily MVIC in PF (Ti; PRE or POST). Each contraction consisted of a 4s isometric phase, preceded/succeeded by a torque increase/decrease of 3s. Torque feedback and target line were presented to the participant on a computer screen. During evaluation session, the dynamometer was used to record the net ankle torque and bipolar EMG from the tibialis anterior (TA) and Triceps Surae (TS; gastrocnemius lateralis, soleus and gastrocnemius medialis) and 64-channels EEG were recorded at 2048 Hz. After appropriate preprocessing, net torque, EMG activation from agonist (EMGAGO) and antagonist (EMGANTAGO) muscles and CMC in between EEG Cz and agonist (CMCAGO) and antagonist (CMCANTAGO) muscles in the 13-31 Hz frequency band were quantified over the isometric phase of the contraction.

**RESULTS:**

Net torque was significantly increased at POST session for the Ti force level in comparison to other conditions. Post-hoc analysis of the ANOVA Time (PRE, POST) x Force Level (T0, Ti) x Muscles (AGO, ANTAGO) revealed that EMGAGO was reduced for T0 in comparison to Ti at POST evaluation. Similar ANOVA conducted on CMC only revealed a main Muscles effect with CMCANTAGO higher than CMCAGO.

**CONCLUSION:**

Our results suggest that neuromuscular adaptations occur as soon as 3 weeks of MST to allow increase torque production. Decreased EMGAGO after MST suggests increased efficiency of the muscle contraction. However, against previous results (3), CMC was not increased with MST suggesting that the central motor adaptation may take longer regarding strength training in comparison to fine motor skills.

- (1) Dal Maso, F. et al. (2012). *Exp brain res*, 220, 287-95
- (2) Dal Maso, F. et al. (2017). *Exp brain res*, 235, 3023-31
- (3) Cremoux, S. et al. (2018). *ICNR*. Springer, Cham, 2018

**NUTRITION****EFFECT OF 8 WEEKS COMBINED TRAINING WITH AND WITHOUT POMEGRANATE CONCENTRATE ON LIVER BIOMARKERS AND PANCREAS IN MIDDLE-AGED WOMEN**

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*SPORT SCIENCE*

**INTRODUCTION:**

Metabolic syndrome is a cluster of metabolic disorders such as central obesity, raised TG level, reduced HDL cholesterol, raised blood pressure and fasting plasma glucose. The combination of risk factors which increase cardiovascular disease, fatty liver and diabetes type II. Healthy lifestyle promotion and rich herb supplement with anthocyanin and phenol are recommendations for treatment. The purpose of this research was to investigate the effects of eight weeks of combined training exercise with and without pomegranate concentrate consumption on liver biomarkers and pancreas in middle-aged women who suffer from metabolic syndrome

**METHODS:**

In this semi-experimental study, 47 middle-aged women with mean, Standard deviation, age and BMI (44.79±3.82 years, 30.53±4.45 kg/m<sup>2</sup>) were selected by convenient and achievable purposive sampling method randomly were divided into groups of Combined exercise group (E(AT+RT)=12) and combined exercise with pomegranate concentrate consumption group (EPC(AT+RT) =12), pomegranate concentrate group (PC=12) who consumed pomegranate concentrate (50 gram per day for 8 weeks), and Control group (CON=12). The aerobic and resistance exercise protocol were conducted with 60-80% an intensity of Maximal Heart Rate (HR max), and 60-80% of One Repetition Maximal (1-RM). The participants in the EPC and PC groups were supposed to consume a daily amount of pomegranate concentrate (50 g) with two 25-gram meals after lunch and dinner (20g). The data were analyzed with SPSS software by Shapiro-Wilk's dependent and independent sample t-test and Levenes test. Significance level was set at P =0.05.

**RESULTS:**

Intergroup changes showed that HS-CRP, Insulin, ALT/AST, AST / ALT ratios and HIS index were significantly different between groups after eight weeks of intervention (P<0.01). However, no statistically significant difference was observed between the groups in terms of glucose, HOMA-IR and HOMA-β levels (P>0.05).

**CONCLUSION:**

It seems that regular physical exercises along with consuming pomegranate concentrate can probably be effective on liver biomarkers through reducing HSI index and β cells by HS-CRP. The hepatic steatosis index (HSI) which is a screening tool aimed at optimizing the management of non-alcoholic fatty liver disease (NAFLD). It is correlated with Insulin Resistance and ALT. IR is a key role for HS-CRP so that this combination can activated the signaling of β cells resting and improvement HSI which can help clinicians identify candidates for liver ultrasonography and those in need of lifestyle and dietary modifications

HSI= 8 x (ALT/AST ratio) + BMI (+2, if female; +2, if diabetes mellitus).

The effect of the combined training with pomegranate concentrate significantly reduced HS-CRP, HSI index and Insulin Resistance levels. Hence, pomegranate concentrate consumption may further improve positive effect of combined exercise training on liver biomarker, pancreas and metabolic syndrome risk in obese middle-age women.

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**DIETARY HABITS INFLUENCING DEGREE OF SATISFACTION WITH DIETING IN CHILDHOOD**

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1. JUE 2. FSH 3. FU 4. JNU, 5. CNU, 6. DWU 7. CU

**INTRODUCTION:**

Different factors such as with whom, what foods, how much, and when people eat impact the satisfaction of their dieting. At the same time, it is feasible that its impact is not involved independently with dieting but is comprehensively associated with it while being interrelated. Thus, in order to examine the unique influence of each dietary habit to its satisfaction, it needs to be investigated it while statistically making the influence of other habits constant. Accordingly, this study investigates dietary habits influencing degree of satisfaction with dieting in childhood by using Quantification Theory Type One (QTT0), which uses dummy variables as independent variables.

**METHODS:**

A questionnaire survey concerning dietary habits in elementary school years was conducted with 858 Japanese male students in September 2017. Questionnaire items were 13 items such as "With whom did you eat breakfast?" "What did you eat for breakfast?" and "What time did you eat breakfast?" In addition, respondents were questioned about their degree of satisfaction with dieting in elementary school years, using a 5-level scale from "1 = very satisfied" to "5 = not satisfied at all." Then, QTT0 was conducted using the degree of satisfaction as a dependent variable and dietary habits as independent variables. The extent to which the dietary habits impact the degree of satisfaction is examined using multiple correlation coefficient (MC), partial correlation coefficient (PC), and the range of category weights (RCW).

**RESULTS:**

The obtained multiple correlation coefficient is R=0.555, indicating high association. The dietary habit with the highest PC and the widest RCW is "With whom did you eat dinner?" with 0.252 in PC and 2.026 in RCW, followed by "What did you eat for breakfast? (PC=0.202, RCW=0.985)," "How frequently did you go to a convenience store or supermarket for food? (PC=0.179, RCW=0.720)," "How frequently did you eat your favorite food repeatedly? (PC=0.177, RCW=0.761)" and "How much did you eat? (PC=0.173, RCW=0.567)." In the category

weights (CW) perspective, the dietary habits that most improved their satisfaction in each question was "All members of the family (CW = -0.118) in "With whom did you eat dinner?" "Noodle (CW = -0.426)" in "What did you eat for breakfast?" "Once per month (CW = -0.391)" in "How frequently did you go to a convenience store or supermarket for food?" "Everyday (CW = -0.439)" in "How frequently did you eat your favorite food repeatedly?" and "Much (CW = -0.181)" in "How much did you eat?"

#### CONCLUSION:

It seems that for dinner which can be eaten without time limits, people gain satisfaction when they eat with many others and eat a large amount of their favorite foods.

### DIFFERENCE IN THE RELATIONSHIP BETWEEN SEASONAL BODY WEIGHT GAIN AND LIFESTYLE-RELATED FACTORS IN MEN AND WOMEN

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#### INTRODUCTION:

Generally, the causes of weight gain are increased daily energy intake and/or decreased physical activity. The weight gain from Thanksgiving to New Year's Day called 'holiday weight gain' is noticed as a factor for long-term weight gain in addition to winter season. According to the National Health and Nutrition Survey (1976-1995), in Japanese adult men, even though body mass index consistently increases, the tendency of energy intake decreases (Yoshiike et al., *Obes Rev.*, 2002). We assumed that a part of this contradiction could be explained by the seasonal weight gain in winter. However, this contradiction is not present in Japanese adult women. This study aimed to confirm the presence or absence and degree of weight gain in the winter holiday season, to determine the lifestyle-related factors associated with weight gain, and to compare these results between the two sexes.

#### METHODS:

The study population comprised 106 men and 195 women (age: 18–22 years). The subjects completed a self-administered questionnaire, which assessed their eating behaviours, dietary habits, physical activity, and sleep habits. Additionally, they reported the presence or absence and degree of weight gain during the winter holiday season. Statistical significance was set at  $p < 0.050$  for all analyses. The correlations between the degree of weight gain and lifestyle-related factors were determined by Pearson's product-moment correlation coefficients.

#### RESULTS:

In total, we analysed 100 men and 190 women. Those who did not answer correctly were excluded. Forty-eight men (48% of all men) and 130 women (68% of all women) experienced holiday weight gain. Average weight gain was 2.2 kg in men and 2.0 kg in women. With regard to men, there was a significant correlation between the degree of weight gain and 'the number of days of consuming sweet drinks in the week ( $r=0.331$ ,  $p=0.022$ )', and 'the length of sedentary time during holidays ( $r=0.386$ ,  $p=0.007$ )'. However, in women, there was a significant correlation between the degree of weight gain and 'the number of days of eating breakfast in the week ( $r=-0.178$ ,  $p=0.043$ )', 'the number of days of eating out in the week ( $r=0.208$ ,  $p=0.018$ )', 'the number of days of part-time work in the week ( $r=0.306$ ,  $p<0.001$ )', and 'the length of sedentary time during weekdays ( $r=-0.200$ ,  $p=0.022$ )'. Exercise and sleep habits were not correlated with the degree of weight gain in both men and women.

#### CONCLUSION:

Half of the men and two-thirds of the women in this study experienced weight gain. The relationship between seasonal body weight gain and lifestyle-related factors was different in both sexes. These differences may contribute to offer approach methods against weight gain and future good health. Further research with a larger study population is required to establish the correlations between measured seasonal body weight gain and taste perception, measured body compositions, and measured physical activity intensity.

### MEDICAL-NUTRITIONAL RISKS IN ENDURANCE COMPETITIONS: RANDOMIZED CLINICAL TRIALS

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#### INTRODUCTION:

Introduction: During the last years the number of competitors in endurance and ultra-endurance sports modalities have increased significantly. This type of competition is an extreme challenge for athletes. Therefore, they have an increased risk of developing medical and nutritional problems.

Aim: analyze the incidence of medical and nutritional risks in endurance and ultra-endurance sports competitions in randomized clinical trials, taking into account the variables that influence them.

#### METHODS:

Methodology: literature review using the Pubmed database and using a search strategy based on keywords (Medical Subjects Headings) separated by screwed connectors. To all the results obtained between 2008-2018, inclusion/exclusion criteria were applied to select those articles that responded to the objective of the review.

#### RESULTS:

Results and discussion: Of the 871 publications identified, 5 met the inclusion criteria. The medical-nutritional problems found in randomized clinical trials are directly related to hydration: exercise-associated hyponatremia (EAH), hyperhydration (HH) and dehydration (DH).

#### CONCLUSION:

The misinformation of athletes about nutrition intake and hydration before and during the competition was identified as the main cause in this type of sports modalities. The main medical-nutritional risk in resistance and ultra-resistance sports is EAH, followed by HH and DH. These risks can affect the performance and health status of the athlete during and post-competition. Several nutritional guidelines have been shown that these medical and nutritional risks can be prevented, it is essential to individualize and adjust to the characteristics of each competition the nutritional intake and hydration reposition.

Keywords: hyponatremia; dehydration; Sport, sports performance



## ASSESSMENT OF ANTIOXIDANT MICRONUTRIENT INTAKE IN THE GROUP OF POLISH PROFESSIONAL ATHLETES

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### INTRODUCTION:

The aim of this study was to assess the content of micronutrients with antioxidant properties in the diet of 171 Polish athletes on the basis of an analysis of 470 whole-day food rations obtained by the method of 3-day nutrition diaries.

### METHODS:

The group consisted of 53 women and 118 men aged 18 to 39 (average  $23.1 \pm 5.3$  years) representing a high level of sport. Athletics (21.4%), volleyball (12.7%) and cross-country skiing (9.8%) are the most frequently practiced disciplines by athletes. The average intake of vitamins A, C, E as well as copper and zinc were referred to the nutritional standards for athletes.

### RESULTS:

The median intake of antioxidant micronutrients in women's diet was generally covered comparing with the standards for the population and only vitamin E demand was 80% of standards. In turn, inadequate intake of zinc (66,44% implementation of standards), vitamin A (99,74%), vitamin E (58,67%) and C (66,37%) was observed referring to standards for professional athletes. The content of zinc, copper, vitamin A, vitamin E and vitamin C was below the standards in diet of professional female athletes, respectively 88,68%, 47,17%, 50,94%, 84,91% and 81,13%. Including supplementation of selected nutrients, the percentage of women below the standards decreased to 21,43%, 8,33%, 15,38%, 22,22% and 25,93% respectively, but 50% women exceeded the upper limit for zinc, 38,46% for vitamin A and 14,81% for vitamin C.

The median supply of antioxidant micronutrients with men's diet provide adequate amounts of nutrients in relation to standards for the population (except for vitamin A). In turn, inadequate intake of most vitamins and minerals was observed referring to standards for professional athletes, except for vitamin A (117,83% implementation). Most of studied men did not provide enough zinc with their diet (61,02%), copper 57,63%, vitamin A (43,22%), vitamin E (73,73%) and vitamin C (78,81%). After implementing supplementation, the percentages of men with micronutrients deficiency in relation to recommended standards for professional athletes were: 4,17% Zn, 15,00% Cu, 10,34% vit A, 10,53% vit E and 34,88% vit C. In turn, 45,83% of men exceeded the upper limit standard for zinc, 51,72% for vitamin A and 20,93% for vitamin C.

### CONCLUSION:

Analysis of the data in diet with supplements reveals excessive intake of all studied micronutrients in the groups above, so the implementation should be controlled by a specialist because of the risk of exceeding upper limits.

Due to the increased demand for antioxidants in sport and insufficient micronutrient supply in the usual diet of athletes it is necessary to educate athletes about proper nutrition and supplementation, especially about zinc and vitamins: E and C.

## PREVALENCE OF LOW ENERGY AVAILABILITY IN FEMALE ELITE YOUTH ATHLETES FROM NON-AESTHETIC/ENDURANCE SPORTS IN SINGAPORE

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### INTRODUCTION:

Low energy availability (EA) in athletes may occur with or without an eating disorder. The clinical consequences of low EA can affect many aspects of physiological and psychological health. In youth athletes, it is important to address and prevent inadequate EA in a timely manner, for optimal growth, health and long-term athletic development. Sports at risk of low energy availability are endurance and aesthetic sports, with other sports often receiving less attention. We therefore explored the prevalence of low EA in Singaporean elite youth female athletes from non-aesthetic/endurance sports, and its correlation with eating disorders.

### METHODS:

48 female national youth athletes from Singapore (mean[SD] age = 16.08 [2.17] years old) completed the Low Energy Availability in Females Questionnaire (LEAF-Q) and Brief Eating Disorder in Athletes Questionnaire (BEDA-Q). Height was measured using a calibrated stadiometer (Holtain Model 602VR). Weight was measured to the nearest 0.05 kg using a calibrated electronic scale (Seca 874) and body mass index (BMI) was calculated as  $\text{weight}/(\text{height})^2$ . As part of the LEAF-Q, the athletes reported their weekly training hours. These athletes (n) came from two team sports - netball (10), waterpolo (11) and three individual sports - canoe sprint (7), badminton (8) and taekwondo (12). Mean[SD] training hours was 16.17 [8.42] hours. A total LEAF-Q score of  $\geq 8$  indicated a risk of low EA. Cut-off for the 3 individual categories of the LEAF-Q was  $\geq 2$  for gastrointestinal symptoms,  $\geq 2$  for injuries, and  $\geq 4$  for menstrual dysfunction. The highest possible score for the BEDA-Q was 18.

### RESULTS:

Prevalence of low EA in the youth athletes was 30.2%, with the prevalence of gastrointestinal symptoms being highest at 39.7%, followed by injuries and menstrual dysfunction at 34.9% and 23.8% respectively. There was no significant difference in LEAF-Q scores between team-based and individual sport athletes ( $t(45) = .513$ ,  $p = 0.610$ ). Results of the Pearson correlation indicated that there was a significant positive association between total LEAF-Q score and total BEDA-Q score ( $r(45) = .343$ ,  $p = .017$ ). No significant correlations were observed between LEAF-Q scores and height, weight, body mass index or training hours of the athletes.

### CONCLUSION:

Considering the high prevalence of low EA in Singaporean elite youth athletes from non-aesthetic/endurance sports, the results of this study highlight that low EA is a pertinent issue in youth athletes. They emphasise the importance of screening for and preventing low EA in youth athlete development. Future studies should look at interventions to prevent and manage low EA in youth athletes. An association with risk of eating disorders, as indicated by the BEDA-Q scores, suggests that preventive measures for low EA should be done in tandem with ED preventive efforts.

## BOOST YOUR STRENGTH TRAINING WITH CAFFEINE.

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### INTRODUCTION:

The ability to generate high levels of power is one of the key factors determining success in many sports disciplines. Previous research has found controversial outcomes about the ergogenic effect of caffeine on power and movement velocity. The aim of the study was to determine the effects of caffeine supplementation on power and movement velocity during bench press training at 70% of 1RM.

**METHODS:**

Three men ( $31.3 \pm 6.6$  yrs.,  $71.7 \pm 10.4$  kg) and three women ( $33.3 \pm 9.7$  yrs.,  $61.9 \pm 1.9$  kg), with at least 1 year of experience in resistance training, participated in a double-blind, crossover and randomized experimental trial. Participants ingested a moderate dose of caffeine (3mg/kg of body mass), or a placebo (cellulose) before strength training. The training protocol consisted of performing 4 sets of 8 repetitions of the bench press movement with a load of 70% 1RM, at maximal speed movement. In each repetition, velocity and power during the concentric phase of the exercise were recorded by using a rotatory encoder at 1000 HZ (Quasar, Isocontrol). Speed loss was calculated from first to 8th repetition, in percentage.

**RESULTS:**

In comparison to the placebo trial, the ingestion of 3 mg/kg of caffeine increased mean velocity ( $0.53 \pm 0.06$  m/s caffeine vs  $0.48 \pm 0.07$  set1;  $0.54 \pm 0.06$  m/s caffeine vs  $0.50 \pm 0.07$  set2;  $0.54 \pm 0.04$  m/s caffeine vs  $0.50 \pm 0.06$  set3;  $0.55 \pm 0.04$  m/s caffeine vs  $0.51 \pm 0.05$  set4; for all sets  $p < 0.02$ ), mean power ( $219.65 \pm 102.64$  w caffeine vs  $194.92 \pm 87.83$  set3;  $p = 0.040$ ,  $218.60 \pm 98.14$  w caffeine vs  $201.52 \pm 95.32$  set4;  $p = 0.004$ ) and reduced speed loss ( $0.25 \pm 0.09$  % caffeine vs  $0.41 \pm 0.15$  set2;  $p = 0.039$ ,  $0.30 \pm 0.11$  % caffeine vs  $0.39 \pm 0.14$  set3;  $p = 0.022$ ,  $0.29 \pm 0.05$  % caffeine vs  $0.41 \pm 0.11$  set4;  $p = 0.050$ ).

**CONCLUSION:**

The ingestion of 3 mg/kg of caffeine enhanced strength training, by increasing movement velocity and power of the bench press exercise and reducing the speed loss. This dose of caffeine could be employed as ergogenic aid in strength training.

**THE EFFECT OF COMBINED RESISTANCE TRAINING AND PROTEIN SUPPLEMENTATION ON FUNCTIONAL OUTCOMES IN FRAIL ELDERLY. A SYSTEMATIC REVIEW.**

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UNIVERSITY COLLEGE ABSALON

**INTRODUCTION:**

Even though age-related decline in physical function can be counteracted to an extent through resistance training, most researchers agree that an adequate amount of amino acids are necessary in order to facilitate training related adaptations. Results of earlier studies on combination of resistance training and protein supplementation on functional outcomes in frail elderly are quite heterogeneous. Therefore, the purpose of this systematic review was to investigate the additional effects of combining protein supplementation to resistance training on functional parameters in frail elderly.

**METHODS:**

Systematic search was conducted using PubMed, EMBASE, and Cochrane Library in October 2019. CASP-checklists and Cochranes Risk of Bias-tool were used to determine the risk of bias.

**RESULTS:**

A total of 10 randomized controlled trials were included (N=785, 176 males; 609 females) with participants between the age group of  $80.1 \pm 4.2$  years. The duration of intervention was 8-24 weeks. Resistance training for the lower extremities using rubber bands or training machines was conducted 2-7 times per week. All the included studies used whey protein, soja protein or multi-ingredient supplements with high protein content. Supplementation was on daily basis in most studies with intakes ranging from 7.1-20.7 g. protein. None of the studies controlled for the total daily energy intake.

No additional effect of resistance training was observed with protein supplementation on 30-sec sit to stand-test, 5x sit to stand-test, FIM-motor score-test, 6MWT, and gait speed test ( $p > 0.05$ ).

**CONCLUSION:**

The findings of this study suggest that protein supplementation to resistance training has no additional benefits on functional parameters of frail elderly compared to only resistance training. However, there is a potential risk of bias in most of the included studies as the daily energy intake was not controlled.

**INTERVENTIONAL STUDY BROWN RICE FEEDING FOR LIVER FUNCTION IN JAPANESE SUMO WRESTLING**

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**INTRODUCTION:**

The sumo is one of the traditional culture in Japan. It was the classic sport that occurred from human competition in strength and scuffle. Due to the hitting the whole body and contact to wrestle with competition partner, the body weight has bigger is an advantage. The professional sumo person, controlled by the Japan Sumo Association who mostly not to consume breakfast, eating two meals in a day. While most of the calories in white and brown rice come from carbohydrates, white rice has a higher glycemic index than brown rice. This means that a serving of white rice provides a quicker blood sugar spike. It was necessary and difficult to maintain performing levels in physical condition without decreasing the body weight. The fatty liver disease is currently the most common form of liver disease and abnormal liver function tests and its prevalence is increasing due to the rise in obesity. The purpose of this study was to investigate effect of brown rice feeding for Sumo over 35 BMI student in especially liver function.

**METHODS:**

Thirteen top level male Sumo wrestling player as volunteer who belong to college Sumo association in Japan (mean  $\pm$  SD; age:  $21.04 \pm 0.98$ ; height  $174.1 \pm 7.94$ cm; weight  $113.8 \pm 19.7$ kg; BMI  $37.6 \pm 6.34$ kg/m<sup>2</sup>) participated in this study. In this experiment, they consumed brown rice as daily meals duration in three months, 15Kg per person at least as an intervention observation. There were three times blood test each term, usual daily meals as before condition, intervention period as three months positive feeding brown rice and after passed returned usual daily meals. This experiment approval in Jissen Women's University ethical committee (No.AC2019-15). It was performed examination of the blood below: cholesterol, and GPTs as liver functions. Values are mean  $\pm$  standard deviation. In each statistical analysis, probability values below 0.05 were regarded as significant. The data were compared by the Statistical Analysis System (SAS Institute, Inc.).

**RESULTS:**

There was no significant difference any between control and brown rice just feeding period and after feeding past. The statistically significant difference was not observed, however, three of subject had changed for the better value in  $\gamma$ -GPT, GOT and cholesterol.

**CONCLUSION:**

This study has limitation as free feeding brown rice and monitoring the physical activity. Therefore, the judgment result of BMI is showed over obese class II according to Japanese setting data. All subjects were within the reference values in both groups in cholesterol (Nakajima, et al, 2018). These results illustrated that repeated high intensity exercise training for Sumo can overcome a distinct subset of the changes in the distal gut and fecal microbiota caused by high-carbohydrate diet for induced obesity, independently of changes in body mass and fat mass.

### **THE EFFECT OF CAFFEINE ON COUNTERMOVEMENT JUMP PERFORMANCE IN RECREATIONALLY TRAINED WOMEN HABITUATED TO CAFFEINE**

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**INTRODUCTION:**

Caffeine (CAF) is a well-researched ergogenic aid commonly used by athletes, in which ingestion elicits a variety of physiological effects that may be beneficial to maximal-intensity exercise performance. Nevertheless, its effectiveness in improving ballistic task performance is unclear, especially in habituated to CAF individuals. Previous studies confirmed that chronic CAF ingestion may modify the physiological and cognitive responses to acute CAF doses, which could negatively impact its ergogenic effect. However, the effects of acute CAF intake have been compared to placebo so far and there are few studies that assess the effect of CAF compared to placebo and control conditions. It is assumed that placebo ingestion does not influence exercise test results, but there are a few pieces of evidence where isolated placebo ingestion provided an ergogenic effect. Interestingly, to date, there is no study that has analyzed the effect of acute CAF administration in those conditions and conducted on habituated to the CAF group. The main goal of this study was to examine the effect of acute intake of 3 mg/kg/body mass (b.m.) of CAF on countermovement jump (CMJ), in women habitually consuming CAF.

**METHODS:**

The study included 17 healthy recreationally trained women (age = 23.1 ± 1.0 years; body mass = 60.2 ± 7.6 kg; BMI = 21.7 ± 2.1). All participants were habitual CAF consumers (3.2 ± 1.2 mg/kg/b.m.; 191.6 ± 72.9 mg of CAF per day). This study had a randomized, crossover, double-blind design where each participant performed 3 different experimental sessions with a one-week interval between each trial. In every session, the participants performed 2 sets of 2 CMJ, with a 3 minutes rest between each set. The differences in peak velocity (PV), jump height (JH) and peak power (PP) obtained during CMJ has been assessed under three different conditions: control test (C) or consumed placebo (PLAC) or 3 mg/kg/b.m. of CAF (CAF-3).

**RESULTS:**

The two-way repeated measure ANOVA (substance × set) revealed no statistically significant interaction and main effects for all measured variables. In comparison to the C and PLAC, the intake of CAF-3 was not effective at increasing PV (2.43 ± 0.36 vs. 2.48 ± 0.45 vs. 0.3 m/s, respectively; p=0.533) nor JH (27 ± 9 vs. 29 ± 11 vs. 27 ± 8 cm, respectively; p=0.417) and PP (2602 ± 511 vs. 2618 ± 520 vs. 2587 ± 401 W, respectively; p=0.871) during 2 sets of the CMJ.

**CONCLUSION:**

The results of this study demonstrated that acute CAF dose, similar to subjects' habitual daily consumption of CAF had no effect on CMJ performance in women. This may suggest that higher doses of CAF, exceeding subjects' typical daily consumption of CAF, may be needed to enhance sports performance.

### **NUTRITIONAL EVALUATION IN JAPANESE SUMO WRESTLER STEW**

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**INTRODUCTION:**

The sumo is traditional and popular culture in Japan. It was the classic sport that occurred from human competition in strength and scuffle. Due to the hitting the whole body and contact to wrestle with competition partner, the body weight has bigger is an advantage. The almost sumo person college sports have not to consume breakfast, eating two meals in a day. Chankonabe or Chanko is a Japanese chicken stew commonly eaten in vast quantity by sumo wrestlers as part of a weight-gain diet. It was served during sumo tournaments is made exclusively with chicken, the idea being that a wrestler should always be on two legs like a chicken, not all fours. Accordingly, it tends to be thought of as growing fatty body and dish with good well. However, there was not enough data to investigate nutrition evaluation of Chanko. Therefore, the purpose of this study was two directionality, for Sumo wrestler's nutrition support service and for ordinary person's impression as the consideration menu of the health.

**METHODS:**

It was selected Kyushu Institute of Information Science as a famous college sports club in Sumo. They often cook their own Chanko behalf of Sumo student. Sometimes, Chnko made Sumo student serve to local resident as the festive season. Their cooking skill were extremely reasonable nevertheless no culinary school course. It was measured weight and mass of food by two students who nutritionist candidate and the person who has home economics teachers license. Chanko by college club sports cooking were polyethism divisions, washing vegetables, cutting vegetables, seasoning of the chicken meat dumpling, work out mince as dumpling, and to put food into a big-hot caldron. It was performed nutritional evaluation by commercial software by Kenpakusha, Japan.

**RESULTS:**

There were 26 items as food into the caldron, minced chicken meat(20Kg), rice wine, egg, soy sauce, Chinese cabbage, frying tofu, sprout, hypsizigus mamoreus, enoki mushroom and seasoning. It was cooking the standard quantity as a stew before 100 for 20 Sumo players.

Global analysis in whole caldron were below: protein 4%, carbohydrate 5%, lipid 21% and salt & vitamin etcetera 70%. There was 45Kcal per 100g cup stew

**CONCLUSION:**

Chanko is a health diet because of rich volume of vegetables, low carbohydrate. Due to the calorie intake, there were a lot of using sesame oil for mice addition as a connection and improved flavor. It was considered that in case of weight-limited competition, Chanko has possibility low calorie diet food both a small amount of oil and chicken breast. The reason for gaining weight was eaten a lot of white rice. It was showed well-balanced meals for sports nutrition to adequate personal conditions.

## A SYSTEMATIC REVIEW OF QUESTIONNAIRES TO SCREEN FOR LOW ENERGY AVAILABILITY (LEA) AND RELATIVE ENERGY DEFICIENCY IN SPORT (RED-S)

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### INTRODUCTION:

Low Energy Availability (LEA) occurs when there is a mismatch in energy intake and exercise energy expenditure (EEE). This can lead to health and performance impairments which are features of Relative Energy Deficiency in Sport (RED-S). Ideally, athletes should be screened for LEA/RED-S risk annually. However, thorough screening may be impractical due to a lack of resources. Questionnaires are simple, convenient tools that can correctly identify symptoms and/or risk factors associated with LEA/RED-S. The purpose of this study was to systematically identify and critically review questionnaires used or developed to measure LEA/ RED-S risk in active populations.

### METHODS:

A systematic search was conducted between January 2010 and July 2020, using the PubMed database. Key search terms included were: Surveys and Questionnaires[meSH] questionnaire OR survey, Relative Energy Deficiency in Sport[meSH], energy deficiency low energy availability, female athlete triad, triad, athletes, exercising men, exercising women. Full-text articles were included if: (i) the questionnaire(s) used in the study identified LEA and/or RED-S risk; (ii) studies developed questionnaires to identify LEA and/or RED-S risk; (iii) study participants belonged to an active population; or (iv) it was available in English.

### RESULTS:

A total of 272 articles were identified, of which 64 duplicates were removed and 173 articles were not relevant. 33 articles met the inclusion criteria and were reviewed. 13 unique questionnaires were identified that measured: (i) LEA symptoms (e.g. irregular menstrual function) (n=2); (ii) Proxy measures of LEA risk factors (e.g. disordered eating) (n=6); or (iii) LEA risk factors and symptoms (n=5). Only three questionnaires included items related to EEE. Eight questionnaires had been validated, with data on sensitivity, specificity, etc. Six questionnaires were designed specifically for females, one for males, and six were for use in both sexes. The most widely used validated questionnaires were the Low Energy Availability in Females Questionnaire (LEAF-Q) (48% articles) and Eating Disorder Examination Questionnaire (EDE-Q) (12% articles). The LEAF-Q determines LEA risk from its associated symptoms but cannot be used in males as nearly half of the items (n=12) relate to menstrual function. The EDE-Q serves as a surrogate marker of LEA risk in both sexes, as it measures a major risk factor of LEA, disordered eating.

### CONCLUSION:

We identified 13 questionnaires used or developed to measure LEA/RED-S risk in active populations. Better validation is needed for many questionnaires and more are needed to address the risk of LEA/RED-S in male athletes. Most questionnaires measure disordered eating or eating disorders (84%) but few measure EEE (23%). To conclude, these questionnaires may be effective in identifying athletes with intentional energy restriction but may be less valuable for those who inadvertently fail to increase energy intake with increased training loads.

## PHILOSOPHY AND ETHICS

## PHYSICAL ACTIVITY PROMOTION

### RELATION BETWEEN QUALITY OF LIFE AND SEDENTARY BEHAVIOUR IN CHILDREN

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#### Introduction

Many children in developed countries lead sedentary lifestyle. This study aimed to examine the relation between health-related quality of life (HRQOL) and sedentary behaviour (SB) among school-aged children, on which little is known (Wu et al., 2017).

#### Methods

To estimate objectively measured daily SB, we asked 92 children (50% girls) aged 9–12 years old to wear a triaxial accelerometer for more than seven consecutive days. Screen-time (ST)-based SB, referring to the duration of watching television, using computers/smartphones and playing video games, were also estimated using the questionnaires of the Health Behaviour in School-aged Children study. The Japanese version of the Pediatric Quality of Life Inventory (PedsQL; Kobayashi et al., 2010) was used to assess HRQOL. Binomial logistic regression models were prepared to estimate the relation between HRQOL as dependent variable and both ST and accelerometer-based SB as independent variables. The PedsQL data were converted into binary variables (high, low HRQOL) according to their mean value. The accelerometer-based SB data for weekdays (<360, 360–419, 420–479, and >480 minutes) and weekends (<420, 420–479, 480–539, 540–599, and >600 minutes) were also converted into categorical variables.

#### Results

The mean and standard deviation of the total PedsQL score was 86.7 (11.6). Low level HRQOL (<86.7) was associated with game use exceeding one hour (odds rate [OR] = 6.4, P = 0.004) on weekdays (model 1). When including categorical data of the accelerometer, model 1 showed that game use exceeding one hour had a significant correlation with low level HRQOL (OR = 6.4, P = 0.004). However, categorical data of the accelerometer and ST variables excluding game use demonstrated no significant relations with HRQOL. As regards weekend data (model 2), low level HRQOL was associated with game use lasting two (OR = 8.6, P = 0.007) and more than three hours (OR = 7.2, P = 0.023). When categorical data of the accelerometer were added to model 2, no significant relations were observed between HRQOL and SB including both ST variables and categorical data of the accelerometer.

#### Conclusion

Our findings suggested that game use exceeding one hour on weekdays and more than two hours on weekends affected the HRQOL of school-aged children. However, no statistically significant correlations were found between HRQOL and accelerometer-based daily SB for both weekdays and weekends. We also provided evidence of the importance to focus on the kind of SB. Although objective measurement, such as that from an accelerometer, is important to estimate the amount of daily SB, devices such as the accelerometer are unable to distinguish among the kinds of activities.

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**WHAT FACTORS MAKE YOUNG PEOPLE DO EXERCISE REGULARLY?**

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 1 FUKUOKA PREFECTURAL UNIV., JPN, 2 JAPAN UNIV OF ECONOMICS, 3 FUKUOKA UNIV., JPN, 4 JEJU NATIONAL UNIV., KOR, 5 DUKSUNG WOMENS UNIV., KOR, 6 CHANGWON NATIONAL UNIV., KOR, 7 CHOSUN UNIV., KOR

## Introduction

It is well known that the habit of regular exercise at a young age brings us desired psychological and social effects, which is important to maintain physical fitness over the whole life and to suppress the risk factors of lifestyle-related diseases (Iiboshi, 2002). For all that, it is said that the ratio of those doing exercise is not so high, indicating males are approximately 29% and females approximately 25% (Healthy Japan 21, 1999). To investigate the measure to have young people do exercise, it is useful to clarify what attributes, life environments, sport experience, family structure and other factors improve or prevent this. Thus, this study statistically investigated factors to discriminate whether they regularly do exercise or not.

## Methods

A questionnaire survey consisting of 14 items about gender, age, daily free hours, means of commuting to work/study, self-evaluation of his or her physical fitness, whether he or she likes PE classes or not, and family structure was conducted on 1,362 N-university students in Japan in January, 2018. Cross tables of whether regular exercise was done or not and each question were tabulated and then a  $\chi^2$  test was conducted. If a significant difference was found, the tendency was examined by using a significantly greater cell after computing a standardized residual.

## Results

As a result of the  $\chi^2$  test, although the item of "Do you take any lesson/practice except for sports?" was not significant, significant relationships at a 0.1% level were found in "Gender ( $\chi^2 = 80.06$ ,  $df = 1$ ,  $p < 0.001$ )," "Age ( $\chi^2 = 34.74$ ,  $df = 7$ ,  $p < 0.001$ )," "Free time on weekdays ( $\chi^2 = 20.26$ ,  $df = 7$ ,  $p = 0.005$ )," "Free time on weekends ( $\chi^2 = 37.44$ ,  $df = 9$ ,  $p < 0.001$ )," "Whether days off are regular or not ( $\chi^2 = 22.14$ ,  $df = 3$ ,  $p < 0.001$ )," "Means of commuting to work/study ( $\chi^2 = 71.92$ ,  $df = 3$ ,  $p < 0.001$ )," "Objective assessment of one's own physical fitness ( $\chi^2 = 62.80$ ,  $df = 3$ ,  $p < 0.001$ )," "Whether you do exercise for maintaining/improving health or not ( $\chi^2 = 249.74$ ,  $df = 1$ ,  $p < 0.001$ )," "Traveling time to sports facilities ( $\chi^2 = 532.31$ ,  $df = 7$ ,  $p < 0.001$ )," "Whether you liked PE classes in elementary school or not = 68.99,  $df = 3$ ,  $p < 0.001$ )," "Whether you have a partner or not ( $\chi^2 = 14.58$ ,  $df = 1$ ,  $p < 0.001$ )," "Whether you have a young child or not ( $\chi^2 = 9.32$ ,  $df = 1$ ,  $p = 0.022$ )" and "Whether you are a person with experience of sports or not ( $\chi^2 = 69.40$ ,  $df = 1$ ,  $p < 0.001$ )."

## Conclusion

In short, when the tendencies were summarized from significantly greater standardized residuals, it was as follows: Many young people who do regular exercise were males, of which their age is young until 22 years old with relatively little free time and regular days off in a week. He or she commuted not by bus or train, but by a motorbike or bicycle. Again, he or she does exercise for good health, liked PE classes in his or her childhood, and has a family who also did regular exercise.

**INTERVENTION EFFECTIVENESS OF PHYSICAL EDUCATION ON PHYSICAL FITNESS OF CHINESE COLLEGE STUDENTS**

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Objective: this paper evaluated the effectiveness of physical education policy in Tsinghua University of China through studying on the physical fitness change of college Students from entrance to graduation.

Method: 3068 undergraduates of Tsinghua University, including 2071 boys (20.74  $\pm$  1.58 years old) and 997 girls (20.35  $\pm$  1.64 years old), were tested from the beginning of enrollment, and then the physical fitness tracking tests were carried out in October every year. Fitness Test Index including: height, weight, vital capacity, grip strength, sit and reach, 50-meter-run, 1000-meter-run (male), 800-meter-run (female), standing long jump, pull-up (male), and sit-ups(female). Using the "national student physical health standards" for scoring and evaluation. Each index has different weight in value score. All the subjects were given physical education class once a week, who were coached by the teacher for 90 minutes, including physical fitness training, sports skills learning and training, etc. Subjects did extra-curricular exercises for 30 minutes at least and two times a week. There were coaches to guide and supervise in the training place, including 3000-meter-run for boys, 2000-meter-run for girls, various ball games, etc. SPSS 20.0 software was used for statistical test,  $p < 0.05$  was significant difference.

## Results:

1. The body shape, vital capacity and sports quality of male and female students had an increasing trend. The height of boys increased by 1cm, reach the mean of 1.75  $\pm$  0.06m, while that of girls increased by 1cm, reach to the mean of 1.63  $\pm$  0.06m; The average weight of male students increased by 3.3kg to 70.24  $\pm$  9.69kg, female students increased by 1kg to 56.42  $\pm$  7.26kg, the vital capacity increased by 356ml to 4246  $\pm$  661ml, female students increased by 224ml to 2909  $\pm$  460ml; the grip strength of male students increased by 6.7kg to 51.2  $\pm$  9.6kgf, female students increased by 5.6kg to 33.8  $\pm$  7.3kgf; the 50 meter run of male students increased by 1.48s to 7.10  $\pm$  0.46s, Girls increased by 1.42s to 8.73  $\pm$  0.58s; boys increased by 17s to 256  $\pm$  27s in 1000m run, girls increased by 19s to 246  $\pm$  22s in 800m run; boys increased by 0.1m to 2.33  $\pm$  0.16m in standing long jump, girls increased by 0.08m to 1.78  $\pm$  0.17m; boys increased by 2.2cm to 14.0  $\pm$  6cm in sitting and reach, girls increased by 3.1cm to 17.7  $\pm$  6.3cm; the mean value of boys pull-up increased by 5, reaching 11.9  $\pm$  7.2 times, and the female students sit ups increased by 10, reaching 44.9  $\pm$  7.9 times/min.

2. The physical fitness of Tsinghua students improved significantly during the four years. The standard score increased from 58.2  $\pm$  13.4 from beginning to 76.4  $\pm$  10.5 when they graduated.

## Conclusion:

The physical education policies and interventions, such as physical education teaching and extra-curricular exercise, had a good effect on improving the physical fitness of Chinese college students, such as body shape, vital capacity, endurance, strength and speed.

## A RESEARCH ON THE CHANGES OF COLLEGE STUDENTS' SPORTS BEHAVIOR IN THE PERIOD OF 2019-NCOV OUTBREAK IN GUANGDONG PROVINCE

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**Introduction:** Since the beginning of the 21st century, the global epidemic situation has been increasing (2003 SARS; 2009 a novel H1N1 Influenza; 2019-nCoV), and the outbreak of the various epidemic virus has threaten to our human beings health and changing peoples living habits, which including people's sports behaviour. The latest 2019-nCoV outbreak has linked to the prohibition of outdoor sports activities, which result in a decreased chance for the college students to be physically active. Therefore, the home-bound students must consciously strengthen physical exercise in a positive way for the purpose to maintain physical and mental health, this is likely predict that both students' explicit and implicit sports behaviors are at a high level.

**Methods:** The college students from two universities in Guangdong Province are selected as follows: Guangdong Polytechnic Normal University and Guangzhou University. After the permission of school administrators, the online questionnaire was distributed to the college students of the two selected universities through the questionnaire network platform, and the students volunteer were asked to fill out the online questionnaire. Statistical software was used to test the difference between the daily and weekly physical exercise time of the two universities' students during the 2019-nCoV outbreak period in Guangdong from 1st February to 1st April.

**Result:** In terms of explicit sports behavior, it shows that the daily physical exercise time was significantly increased, the way of participating sports was also significantly increased.; in terms of implicit sports behavior, it shows that the attitude of students participating in physical exercise becomes positive, the sense of sports performance increased significantly compared with Non-epidemic period, and the vast majority of college students surveyed have the strong willing to continue to participate in physical exercise in the future.

**Discussion:** The findings revealed that after the outbreak of the 2019-nCoV, the college students first changed their explicit physical behavior followed by implicit physical behaviour and the indoor sports activities are all increased significantly. In the past, many students who seldom took part in physical exercises also took the initiative to change their physical behavior into indoor sports. The occurrence of a major epidemic, like two sides of a coin, is a threat to students fitness, but also promotes the change of students' indoor sports behavior.

## PHYSICAL ACTIVITY, HEALTHY HABITS AND TEACHING LESSONS BY PHYSICAL EDUCATION TEACHERS DURING THE LOCK-DOWN

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GENERALITAT VALENCIANA

Physical activity, healthy habits and teaching lessons by physical education teachers during the lockdown

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Generalitat Valenciana (Department of teaching)

### INTRODUCTION:

Physical Education teachers (PE teachers) have been forced to change their way of teaching due to the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Being accustomed to the practise and promotion of Physical Activity (PA), their lifestyle has been significantly altered. This study aimed at comparing PE teachers' PA practice before and during the confinement; their habits, lifestyle and teaching during that time.

### METHOD:

A descriptive epidemiological study with 2757 teachers (men = 1767; women = 990), differentiated by age, Autonomous Community (AC), degree, teaching stage and employment situation. The data collection was done with a completed questionnaire. Qualitative variables were analysed. To compare and to know their possible dependence or independence between them, the chi-square test was used. Statistical significance was established at  $p < .05$ . The level of association between two dependent variables was analysed with Phi and Cramers V (between 0 and 1).

### RESULTS:

98.5% did PA before, of which 44.3% were regular practitioners 3-4 days a week. During the confinement, 95.5% did PA with 33.2% doing it more than 5 days a week. The days per week of PA practice and their practice time are variables that show statistically significant dependency during confinement ( $\chi^2 = 2194.025$ ;  $p < .05$ ) and a significant positive association level between them ( $\Phi = 0.892$ ;  $p < .05$ ). Practice days with shorter duration increased. Self-loading exercises (26%) and aerobics (22.7%) are the most practised. 66.3% are leading a less healthy lifestyle. The habits that have increased the most are time spent with a mobile phone (85.9%) and watching TV (64.2%), with the PA practise time being the one that has decreased the most (59.1%). The measure of staying at home (2305; 27.9%), followed by frequent hand cleaning (2167; 26.2%), were considered the most effective to avoid contagion. 60.5% consider the Physical Condition and Health content the one that has best adapted to the teaching-learning process during the confinement. 54.7% consider their Information and Communications Technology (ICT) training to be fair.

### CONCLUSION:

Considering that the coronavirus is likely to last for some time, it would be advisable to provide objective data that establish greater precision between the relationship between physical activity-COVID-19. Further studies should be carried out to help ensure regular PA practice safely, given the benefits it produces in peoples health. In relation to teaching PE, it would be interesting to create meetings or working groups with joint actions, where teachers can collect and make proposals on teaching, in addition to ICT training courses in PE.

## PHYSICAL ACTIVITY AND SLEEP IN KINDERGARTEN CHILDREN IN HONG KONG

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THE EDUCATION UNIVERSITY OF HONG KONG

Physical Activity and Sleep in Kindergarten Children in Hong Kong

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### Background

Sufficient physical activity (PA) is important for maintaining the health status of children. The purpose of the present study was to investigate the PA level and sleep quality in Hong Kong kindergarten children.

#### Methods

Totally 137 kindergarten children aged between 3 and 5 yrs in Hong Kong participated in the present study. Participants were instructed to wear the accelerometers on the left wrist for 7 days excluding sleeping and bathing. Two questionnaires, i.e., Netherland Physical Activity Questionnaire (NPAQ) and Children's Sleep Habit Questionnaires (CSHQ), were completed by their parents.

#### Results

Totally 81 children (48 boys and 33 girls) provided valid accelerometer data for further data analysis. Only 32.1% of children in the present study met with the PA guideline. Boys had a higher total PA level and moderate-to-vigorous PA (MVPA) level than girls ( $P < 0.05$ ). No difference was found in NPAQ total score between boys and girls, and the score was positively correlated with MVPA. For the CSHQ data, gender differences were found in the score of sleep disordered breathing and daytime sleepiness.

#### Conclusion

The PA level and sleep quality of kindergarten children in Hong Kong should be further improved. The accelerometer and NPAQ could be used together to better assess the PA level and understand the PA pattern of kindergarten children.

Keywords: Kindergarten children, Physical activity, Sleep quality

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### THE "BADMINTON FOR ALL" PROJECT: A CURRICULUM TRAINING TO PROMOTE PARTICIPATION OF PEOPLE WITH DISABILITIES IN EUROPEAN CLUBS

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1B4ALL PROJECT. 2CLUB B4MINTON CHAMARTIN. 3UNIVERSIDAD POLITÉCNICA MADRID. 4UNIVERSIDAD PONTIFICIA COMILLAS. 5UNIVERSIDAD CORUÑA. 6 BOURNEMOUTH UNIVERSITY & UNIVERSITY OF KENT. 7UNIVERSITY OF GRANADA

#### Introduction

Sport participation rates of people with disabilities (PwD) are very low compared to general population, especially at grassroot level (EU, 2014). This is also applicable to badminton, a sport that will become Paralympic at the forthcoming Tokyo Games. To tackle this challenge, an European project entitled "Badminton for all: European network for the promotion of inclusive Badminton (B4all)" received funding from the European Commission at the "Erasmus+" call (2018-2020). The project is headed by the Spanish Badminton Federation. One of the most important outcomes of B4all relates to the inclusive training of sport staff (coaches – physical education teachers, club managers, referees and volunteers). The overarching aim of this study was to design an inclusive badminton specific curriculum to provide specific continuous training to the diversity of sport professionals who are involved with badminton and PwD.

#### Methods

Two experts in badminton and two experts in adapted physical activities and sport for PwD participated in the curriculum design and development. All of them had experience in training and teaching in the wide range of academic and badminton sport levels. The proposal took into account main badminton inclusion needs, the latest innovative and online tools and the sport specific training opportunities.

#### Results

The curriculum is structured in three different training units: a common unit "Disability, sport and inclusion" (6 hours for all staff profiles composed by the following six lessons: disability and health, main types of disabilities, communication with PwD, sport with PwD, PwD and their rights to sport, physical activities and inclusive sport), a specific unit "Inclusive practice of Badminton" (8 hours, composed by the following six lessons: the inclusive model of badminton, assistance to PwD in Badminton, inclusion as a service in Badminton structures, adaptations to the inclusive practice of Badminton, organization and promotion of inclusive activities and competitions in Badminton, proposal of inclusive Badminton sessions) and a practical unit titled "Participation in real inclusive Badminton activities" (5 hours).

#### Discussion

Training in how to include PwD in badminton clubs to the diversity of sport staff involved is crucial to foster participation at grassroot level. With the competences, skills and knowledge derived from the proposed curriculum, social inclusion through badminton practice will be enhanced. Equal opportunities and awareness of the importance of health-enhancing physical activity through increased inclusion of PwD in European badminton clubs will be facilitated through the deliverables of B4all.

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### CURRENT STATE OF PHYSICAL STRENGTH IN JAPANESE FEMALE PRESCHOOL CHILDREN IN RECENT YEARS

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Due to Japan's high economic growth, a society that values intellectual development was accepted, children no longer played outdoors, and free time for physical development was lacking. Well-known study of the decreased physical fitness of children found that the physical strength and motor ability of children today is quite poor relative to their body size (Nishijima, 2002). Particularly low were physical functions and abilities that don't appear in the results of physical strength measurements, for example activities and motor performance that occur in actual daily life. There is also thought to be a risk of losing the "inner potential for growth" to live as a human. A recent physical fitness and motor ability survey (6-15yrs old : 2018) by the Ministry of Education, Culture, Sports, Science and Technology indicated that while physical fitness does not reach the level of that in 1985, the decline has stopped. Even though the decline has stopped, however, there has not been a return to past levels and physical strength is without question low relative to body size. Akimaru (2003) compared the physical fitness results of preschool children from the changes over time in the 30 years between 1969 and 1999, and showed that while in some activities there was a decreasing trend, in others there was an increasing trend. This suggested that, depending on the activity, there were in fact some rising trends among preschool children. Why would secular trends in physical fitness and motor ability differ between preschool children and schoolchildren?

The purpose of this study was to clarify the trends since 2000 in body shape, physical strength, and motor ability in early childhood in Japan. Subjects were Japanese preschool girls (age 3-5 years old). Physique (height and weight), quantitative motor ability (20m dash, standing long jump, tennis ball throw, side step, one-leg hop, jump rope, hanging from a horizontal bar, one-leg standing, and ball bouncing), and general motor ability (jump over and under) were compared in the 1999 and 2009 (and 2019\*) school years. The results revealed

that, compared with ten years earlier, height was 0.9cm shorter in 4-yr-old girls and weight was 0.3kg lighter in 3- and 4-yr-old girls in 2009. In physical strength and motor ability, the time for jump over and under was shorter in 3-yr-olds, the number of times a rope jump was higher and the time hanging from a horizontal bar was longer, and the time for jump over and under was shorter in 4-yr-old. In 5-yr-old, only an increase in the number of times a rope jump increased. The tennis ball throw and side steps were not significantly different from 10 years earlier in any of the ages. Physique, physical strength, and motor ability improved with growth, but compared with 10 years earlier many of the items were found to decrease or remain the same in all ages. (\*In 2019, we conducted a survey of preschool children with the same content. Make the results as public as possible.)

## PHYSICAL EDUCATION AND PEDAGOGICS

### THE EXERCISES USED IN PE GYMNASTICS IN RELATION TO STUDENTS ATTITUDES

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#### Introduction

As an integral part of PE classes, gymnastics has always been a significant area. Gymnastics movements are most apt to develop spatial perception, strength control, and movement coordination. In addition to psycho-motoric advantages, they also have a highly beneficial impact on areas of cognitive and affective development (aesthetics, courage, will power, problem solving skills). Our research was focused on this area, generally believed by PE teachers to be hard to teach, examining it from the students' point of view.

#### Methods

The students of a vocational secondary school in a middle-sized Hungarian town, aged 15-18 ( $\pm 0.35$ ), participated in the examination (n = 126, 70 male, 56 female). As the method of cross-section examination an online survey was used. The questions were mainly grouped around: the popularity of the kinds of sports offered in school; a spectator's and practical understanding of gymnastic movements; emotions felt when practising gymnastics; support received from the teacher, and attitude towards gymnastics. Based on the answers received, descriptive statistics have been compiled. We used factor analysis to break down the answers into group by the emotions felt during practising gymnastics. We used correlation analysis to investigate how the factors were related in terms of the students' previous relationship with gymnastics and the habit of the PE teacher to provide support.

#### Results

Football and table tennis ranks high on the popularity list of the sports in PE class (3.41 and 3.38 respectively), whereas swimming, athletics and gymnastics ranked the lowest (2.92, 2.97 and 2.97, respectively).

Based on the 21-question survey on the attitude towards gymnastics, two factors could be identified. Factor 1 includes responses showing fundamentally negative emotions about gymnastics, ones finding the moves difficult and the students feeling clumsy and rarely successful. Factor 2 includes responses showing fundamentally positive emotions about gymnastics, and attitudes identifying gymnastics as an experience and a success. Factor 1 (negative attitude) shows medium positive correlation with sex ( $r = .239$ ;  $p = .007$ ) (greater with women), and weak negative correlation with the support received ( $r = -.201$ ;  $p = .024$ ). Factor 2 (positive attitude) shows medium negative correlation with participation in a competition ( $r = -.277$ ;  $p = .002$ ), and medium positive correlation with teacher support being unnecessary ( $r = .249$ ;  $p = .005$ ).

#### Discussion

When it comes to gymnastics movements, students are familiar mostly with the movements of the vault and floor gymnastics, which is attributable to the fact that schools are poorly equipped with instruments, and teachers are uncertain about teaching gymnastics. Our examination clearly pointed out the responsibility of the PE teachers whether or not they are able to spark interest in students, and create a teaching environment, making them feel safe when doing gymnastics.

### EFFECTS OF LONG-DISTANCE RUNNING IN SCHOOL PHYSICAL EDUCATION CLASSES WITH A FOCUS ON INDIRECT COMPETITION

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In most Japanese physical education (PE) classes in schools, students run for long distances. However, Japanese students tend to not have a positive attitude toward long-distance running in PE classes. To address this difficult situation, many studies on long-distance running in PE classes have been conducted in Japan. However, most of these studies focus on improving students' records. Furthermore, little is known about the effects of long-distance running in school PE classes with a focus on competition. There are two types of competition: direct competition and indirect competition. We hypothesized that, with indirect competition, students would have a more positive attitude toward long-distance running. Therefore, this study focused on indirect competition and aimed to analyze the effects of long-distance running in school PE classes with a focus on indirect competition. Considering the purpose of the study, we set the following two research questions: 1) Do participants' attitudes toward long-distance running improve when they engage in long-distance running in school PE classes with a focus on indirect competition? 2) RQ2: Is participant stamina improved by learning in these PE classes?

The participants of this study were 80 first-year junior high school students. A questionnaire, developed based on Koiso et al. (2018), was conducted as pre- and post-tests. The questionnaire was administered to participants at the beginning and at the end of the learning unit on long-distance running. By analyzing the results of the pre- and post-tests, we examined whether the participants' attitudes toward long-distance running improved after long-distance running in school PE classes focusing on indirect competition. With regard to RQ2, the duration of participants' 1500-m run was recorded at the beginning and at the end of the learning unit. By using these measurements, we examined whether participants' stamina was improved as a result of these classes.

The results of the questionnaire survey indicated that there was a statistically significant difference ( $p < 0.05$ ) between the pre- and post-test for long-distance running PE classes with a focus on indirect competition because of factors of "engagement," "achievement," "collaboration," "favorability," and "unpleasantness." Furthermore, the recorded duration of the 1500-m run showed that the participants improved their stamina, with a statistically significant difference ( $p < 0.05$ ) between the pre- and post-test runs.

In conclusion, long-distance running in school PE classes with a focus on indirect competition can effectively help students develop a positive attitude toward long-distance running and improve their stamina.



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### **ATTENTION OR KINEMACTICS? THATS THE QUESTION TO TEACH FITNESS EXERCISE.**

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Attention or kinematics? Thats the question to teach fitness exercise.

Introduction

Usually we don't give enough importance to external focus of attention in traditional training during instructions and yet we pay only attention just to the internal focus to create movements.

This situation tie down people think in kinematics movement instead of the goal of the task.

Physiologically this situation impairer motor learning and increases the perceived effort with the same workload, between other negative effects during the training.

In the actual context, we need different approaches to get easier the practice of physical exercise to keep and improve health or to treat injuries and illness, since it has been already widely evidenced the positive rol of the muscular contraction in the cognitive, physiological, functional or behavioral level.

The use of attentional focus has been studied in sports, in day life task (as balance) or in some fitness exercises including the biceps curls or abdominal crunches, but we haven't been able to access the results of the study during the stoop tasks and standing up to pick up weights from the ground, which has been deeply studied in ergonomics studies or in the classical exercise known like Deadlift.

Methods

In experimental study, participants without knowledge about strength training are divided by randomized blinded envelopes.

All groups have to do the task "lift a barbell from the floor to the hip".

Group one do the task only instructed by information "only try to be straight your spine", the second group is instructed using "only try to push the floor with your feet", and the group three is instructed by information "lift the weight"

All data are analyzed and registered by descriptive statistics. Trustworthiness is ensure trough several processes as inclusion and exclusion criteria.

Objetives

The objetive is to measure by a surface electromyography (EMGS) the activation ratio of the knee extensors muscles related to the trunk back muscles, the fatigue perceived and the variability in the movement kinematics measuring the range of movement in both areas.

Results

Results shows that using the external focus decrease the fatigue and the EMG of the spine extensors, at the same time that increases the activation of the knee extensors and also the variability of the movements kinematics.

Conclusion

Based in that data, this article add information that the use of the external focus during motor learning of daily life tasks or training it is appropriate, and specifically during bending to pick up an object from the floor.

### **INFLUENCE OF THE DIFFERENCE IN THE INSTRUCTIONS AS TO A RUN-UP ON THE RUN-UP SPEED AND THE JUMPING DISTANCE IN RUNNING LONG JUMP IN HIGH-SCHOOL PHYSICAL EDUCATION LESSON**

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Purpose: The aim of this study was to demonstrate how the difference in instructions as to run-up speed influences the run-up speed and the jumping distance in running long jump in high-school physical education lesson.

Method:66 male students (age, 15.2±0.4 years; body height, 168.2±6.6 cm; weight, 56.2±11.3 kg) who are on the first grade of a technical junior college in this study.We gave different instructions for 2 classes. Measurement was conducted twice, and an instruction, "Run rhythmically as usual for the first jump, and run at full speed for the second jump", was given to subjects in A class, and another instruction, "Run at full speed for both the first and second jumps", was given to subjects in B class.

Results: There was a significant positive correlation between run-up speed and jumping distance ( $r=0.718$ ,  $p=0.001$ ).Significant increase in run-up speed from the first jump to the second jump was noted in both A class and B class (A class:  $p=0.001$ , B class:  $p=0.05$ ). In addition, the rate of change was significantly greater in A class than in B class ( $p=0.01$ ). In comparison between A class and B class in the first jump and the second jump, there was a trend that run-up speed was significantly higher in B class compared to A class in the first jump, but significant difference was not observed ( $p=0.07$ ), and there was no significant difference between groups in the second jump ( $p=0.60$ ).In A class, there was no significant correlation between the run-up speed and the jumping distance ( $r=0.352$ ,  $p=0.137$ ), while there was significant positive correlation between the run-up speed and the jumping distance in B class ( $r=0.549$ ,  $p=0.008$ ).

Conclusions: Based on above findings, a following possibility was suggested: Jumping distance increases with the increase in the run-up speed when subjects run at full speed as done in B class, but subjects lose balance in other phases than run-up such as "the take-off", "the flight through the air (posture control)", and "the landing" due to increased run-up speed when subjects adjusts their run-up speed as done in A class, and an increase in the run-up speed does not always lead to improvement in jumping distance.

### **PEDAGOGY OF NON-CONCENTRIC MARTIAL ARTS**

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INTRODUCTION:

Non-concentric Martial arts are martial arts that do not use concentric muscle contraction or known as "brute force" according to the principle of store and issue strength in Chinese classical literatures. The aim of this paper is to investigate the difficulties in learning these arts whether they are psychological, physiological, or both.

METHODS:

A set of techniques was developed by a panel of long time practitioners and coaches of Qigong and non-concentric martial arts which included Taijiquan, Xingyiquan, Baguaquan, Yongchunquan (Wing Chun), to check the correctness of learners. The panel consisted of 3 ladies and 8 men, age between 50 and 83 years of age with an average of over 20 years of experiences. There are also 4 external members located in the UK, Hong Kong, China, and New Zealand. The set involves passive stance, static one arm press, passive arm curl, and two arm curls to handle weights over one repetition maximum, to test relaxation, eccentric strength, stored elastic energy, and stored elastic energy upon eccentric strength. Members of the panel were asked to test their students, friends, and associates directly or via internet, and report on their findings in 2019.

#### RESULTS:

The results were positive when subjects are under supervision with a clear objective of utilizing eccentric strength and stored elastic energy, and the method of testing is workable even with beginners, and there was no difficulty in introductory workshops with people without any background in martial arts or soft exercise. The apparent difficulty in the application of non-concentric techniques is psychological. Subjects under supervision and in a non-stressful environment they can perform positively but fail under any adverse stimulant that stressed them and they contract concentrically. This research confirmed the advantage of eccentric strength and restored elastic energy, and the difficulties in applications are as suggested in Chinese classical literatures of "use no brute force".

#### CONCLUSION:

The difficulties in learning non-concentric martial arts are unique in developing skills without the component of concentric muscle contraction, and it is known that stress and anxiety are the causes of concentric muscle contraction which can effects performance in a greater degree compare with other skills made use of both eccentric and concentric components. The common view in the martial arts community is that it takes longer time to develop skills in non-concentric martial arts than other martial arts, There are other variables such as age, sex, racial, cultural, the length of time training in other sports or martial arts, etc., which require considerations in teaching. It is suggested that further research is required to investigate the advantages of adherent training such as pushing hands, sticking hands, and two person adherent sets, as a method of resolving stress and anxiety in applications.

### THE INFLUENCE OF EXPERIENCE USING ICT TO PE CLASSES

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#### Introduction

This study aimed to investigate the influence of experience using ICT on PE classes while holding an inherent likeness of PE classes or the communication competency of students as the constants.

#### Methods

The subjects were 173 freshmen in the S- College of Technology who took a PE class. NHK (Japan Broadcasting Cooperation) radio gymnastics using ICT was taught and after that, a questionnaire survey was conducted. The items of the survey were six items on the condition of individuals before their classes such as "The extent to which they habitually exercise" and "Their like or dislike of PE classes," and seven items on how much the students feel about using ICT in PE classes: "fun," "eagerness" and "communication." Quantification Theory Type Two (discriminant analysis with a categorical data as independent variables) was conducted using an individual condition before the classes as a dependent variable and the reflections of ICT-use PE classes as independent variables. From the partial correlation coefficients (PC) obtained from that, the influence of experience using ICT on PE classes was investigated while holding an inherent likeness of PE classes or communication competency of students as the constants.

#### Results

Multiple correlation ratios obtained by the reflection indicated a middle association with 0.455 to 0.60. Six PCs higher than 0.2 were found in 2) Their like or dislike of PE classes, four in 3) Whether or not they are good at exercise/sports and 4) Whether or not they are good at communicating with others, and two in 1) The extent to which they habitually exercise, indicating that habitual positive feelings for PE classes or exercise/sports favorably impacted on PE classes using ICT.

In the PC of 5) Their experience of using ICT besides in PE classes that is thought to hold inherent likeness of PE classes or communication competency of students as constants, PCs higher than 0.2 were found in e) activity and g) a sense of fulfillment. However, no PC higher than 0.2 was found in 6) Their experience of using ICT in PE classes.

#### Discussion

In the influence of this PE class, of which the subject is radio gymnastics, a big impact in terms of an individual's positive feelings for PE classes or their communication capacity was found but that of ICT experience was not so much. It seems that this is because high level skills or communication capacity are not required for the simple movements of radio gymnastics. On the other hand, more association was found in the class evaluation for 5) Their experience of using ICT besides in PE classes than for 6) Their experience of using ICT in PE classes. This seems to be because the freshness or originality of using the generally used ICT in PE classes elevated the students' class evaluation. Considering this, it is important that while cooperating with other subjects in addition to PE classes, the use of ICT devices is also introduced to other subject classes.

### CHANGES IN EXERCISE FREQUENCY AND TIME DURING FACE-TO-FACE LESSONS, SCHOOL HOLIDAYS, AND ONLINE LESSONS: ONLINE QUESTIONNAIRE SURVEY FOR STUDENTS AGED 16-17 YEARS

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[Title]

Changes in exercise frequency and time during face-to-face lessons, school holidays, and online lessons: Online questionnaire survey for students aged 16-17 years

[Introduction]

The COVID-19 had a great impact on medical and educational scenes. In Japan, more than 90% of schools were closed in March 2020. Many schools started online classes for the new semester. Since online classes can be taken remotely, infection risk can be suppressed; however, it is expected that exercise frequency and time may be significantly reduced. This study investigated changes in exercise frequency and time during face-to-face lessons, school holidays, and online lessons.

[Methods]

The study conducted a weekly online questionnaire survey from May 11 to June 12, 2020, on 210 men and women aged 16-17 years from National Institute of Technology, Yonago College. The questionnaire surveyed the exercise frequency per week and the average exercise time per day for each face-to-face lesson, school holiday, and online lesson.

[Results]

In comparing exercise frequency per week between face-to-face lesson and school holiday, the ratio of 0 days increased (face-to-face lesson 3%-school holiday13%,  $p<0.05$ ); however, the ratio of 3 days or more decreased (face-to-face lesson 83%-school holiday62%,  $p<0.05$ ). The average exercise time per day decreased during school holidays than during face-to-face lesson (face-to-face lesson 78 minutes-school holiday 38 minutes,  $p<0.05$ ).

Furthermore, in comparing exercise frequency per week between face-to-face lesson and online lesson, result showed no significant difference in the ratios of 0 days and 3 days or more. The average daily exercise time significantly decreased during online lessons than during face-to-face lessons (face-to-face lesson 78-online lesson 42 minutes,  $p<0.05$ )

[Discussion and Conclusion]

Result revealed that it was possible to clarify the changes in the exercise frequency per week and the exercise time per day during face-to-face lesson, school holiday, and online lesson. First, it was found that exercise frequency and time significantly decreased during school holiday than during face-to-face lesson and that face-to-face class guaranteed the opportunity to exercise.

Second, there was no significant difference in the percentage of exercise frequency at 0 days between face-to-face and online lessons. In addition, there was no significant difference in the ratio of 3 days or more.

In online physical education class, more than 4 days a week and 15 minutes or more a day of exercise tasks were given. Therefore, physical education classes play an important role in maintaining opportunities for students to exercise during online classes.

## EXAMINING THE POSSIBILITIES FOR CREATIVITY EDUCATION IN PHYSICAL EDUCATION LESSONS IN JAPAN

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Examining the Possibilities for Creativity Education in Physical Education Lessons in Japan

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INTRODUCTION:

Among its many goals, Japan's Basic Act on Education seeks to foster creativity. However, according to an international comparative survey conducted by Adobe in 2017, only 8% of Japanese students think of themselves as creative, as against 47% in the United States and 44% in Germany. Similarly, among teachers, the percentage is 2% in Japan, as against 25% in the United States and 26% in Germany (Adobe, 2017). Thus, school education does not fulfil a key goal of Japan's educational policy. On the other hand, several researchers have pointed out the possibilities for creativity education in physical education lessons. (Uto, 1967; Nanba, 1985; Fukazawa, 2006) However, within Japanese school education, the subjects that have been associated with creativity thus far are mathematics, science, art, and music. Therefore, in the current study, we examine the potential of physical education lessons to foster creativity in students through practical lessons.

METHODS:

The study involved 45 fifth year-students (20 years old) of X technical college in H prefecture. We implemented a practical lesson using the student participation approach (Hayashi, 1999), which is a proven method for fostering creativity. In addition, we created 33 questionnaires based on the componential model of creativity developed by Cropley (2001), and analysed which elements related to creativity were developed through the practical lessons. The average scores before and after practice were compared and a t-test was used to confirm that the differences were significant.

RESULTS:

The results confirmed that most elements of the componential model of creativity showed improvement following the practical lesson, particularly 'fluency', 'restructuring and redefinition', 'logical thinking', 'critical thinking', 'steadfastness and persistence task commitment', 'flow', and 'leadership'. These differences were also confirmed to be statistically significant.

CONCLUSION:

From the analysis results of the answers on the questionnaire, it was found that this practical lesson could improve the creativity of students. In particular, Burcu et al. (2020) also pointed out the relationship between creativity and leadership in physical education lessons, and obtained the same results.

## PHYSIOLOGY

### EFFECTS OF SPORTS ON CARDIAC REMODELING IN YOUTH ATHLETES PLAYING DIFFERENT SPORTS

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INTRODUCTION:

Long-term sports training leads to specific cardiac remodeling in adult athletes' hearts, including ventricular hypertrophy, atrial dilation, aortic dilation, as well as improved systolic function and diastolic filling. However, how long-term sports training will affect youth athletes' hearts during different periods of their training life and how different loads on the cardiovascular system affect the athletes' cardiac remodeling has not been fully understood. In this study, we aimed to reveal changes in the athletes' hearts, their maturational growth patterns, and different heart performances caused by the different cardiovascular loads.

METHODS:

A prospective study was conducted using real-time portable echocardiography. Five hundred Chinese youth athletes have measured heart parameters, power capability, and diastolic function, they were classified according to age, gender, type of sports, level of performance, and weekly training-duration. Heart parameters included diastolic interventricular septum, diastolic left ventricular posterior wall, relative wall thickness, diastolic left ventricular internal diameter (LVIDd), systolic left ventricular internal diameter (LVIDs), aortic root diameter, systolic left atrium, indexed LVIDd, indexed LVIDs, left ventricular mass, and left ventricular mass index. Power capability included left ventricular end-diastolic volume, left ventricular end-systolic volume, stroke volume, heart rate, cardiac output, left ventricular ejection

fraction, and short-axis fractional shortening. The diastolic function included mitral valve diastolic early velocities (E), mitral valve systolic decline time, left ventricular lateral wall late diastolic velocities ( $e'$ ), and  $E/e'$  ratio.

#### RESULTS:

Cardiac remodeling could occur in most of the youth athletes, including obviously increased heart parameters that indicated enlargement of the heart and relative improvement of heart power capability. Little changes were brought to diastolic function, and the growth factor had greater effects than long-term exercise training. Male youth athletes showed improved power capability, and female youth athletes showed improved diastolic function. Aerobic sports led to greater cardiac remodeling, including increased heart parameters and improved heart function, compared with mixed-oxygen sports in our study. Only wall thickness showed different results compared with those among adult athletes. Training more than 15 hours a week contributed to cardiac remodeling among youth athletes, but overlong weekly training did not bring greater changes. Cardiac remodeling existed in different groups based on the level of performance. With the improved level of performance, the results of cardiac remodeling were more obvious among the first-grade athletes. As for the elite participants, the path of cardiac remodeling changed. Moreover, total training history did not cause differences in the level of performance.

#### CONCLUSION:

This study proved the existence of cardiac remodeling among youth athletes. Remodeling occurs over time in response to high levels of sports training, including measured parameters, power capability, and diastolic function. Gender and sport type led to different changes compared with those in adult athletes. Weekly training-duration and level of performance contributed to cardiac remodeling, too. Our study can help with the selection and training of excellent youth athletes.

### A STUDY ON BONE MINERAL DENSITY AND BODY MINERAL CONTENTS OF LEFT & RIGHT ARMS, LEGS AND SPINE IN COLLEGIATE ATHLETES

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#### INTRODUCTION:

INTRODUCTION : This study aims to evaluate these data from national team-class modern pentathlon male athletes to measure the bone mineral density of these athletes and further to compare with BMD of other sport's athletes. In addition, the purpose of this study is to analyse and utilize these data as an important determinants for developing bone health and professional physical training programs for modern pentathlon athletes.

#### METHODS:

METHODS : The subject of this study was selected 14 modern pentathlon male athletes who understood and expressed their willingness to participate this study actively. The bone mineral density measurement equipment was used GE Lunar iDXA(GE Medical System Lunar, USA) with the principle of dual-energy radiation absorption(DEXA) and measured head, arms, legs, trunk, ribs, pelvis, spine, whole-body bone mineral density and bone mineral contents, respectively. These data of this study were compared with and discussed the results of the other precedent studies[1][2] using the same equipment as this method of measurement.

#### RESULTS:

RESULTS : Bone mineral density of left arm, left leg, left total, right arm, right leg, right total in modern pentathlon athletes was 1.02g/cm<sup>2</sup>, 1.45g/cm<sup>2</sup>, 1.24g/cm<sup>2</sup>, 1.05g/cm<sup>2</sup>, 1.46g/cm<sup>2</sup>, 1.26g/cm<sup>2</sup>, respectively. and there was a significant difference between left and right for arm, and a significant difference between left and right for upper body, but no difference between left and right legs. BMD of pelvis, spine, total body, TBLH was 1.30g/cm<sup>2</sup>, spine 1.05g/cm<sup>2</sup>, total body 1.25g/cm<sup>2</sup>, TBLH 1.17g/cm<sup>2</sup>, and BMC of total body, TBLH was 3,144.13g, 2,648.29g, respectively. When compared with other studies, arm was lower than BMD of wrestling, ssireum and judo, but was higher than taekwondo and boxing. Leg was lower than BMD of ssireum, judo, wrestling and taekwondo. Spine was lower than BMD of most martial arts such as ssireum, judo and wrestling. In this study, the bone mineral contents of modern pentathlon athletes were 2,648.3g at TBLH, which was higher than swimmers 2,214g, footballers 2,116g and cyclists 2,189g in other precedent studies.

#### CONCLUSION:

CONCLUSION : For BMD of modern pentathlete, legs, pelvis was higher, and ribs, trunk, spine was lower, than average values of total body and at TBLH. The right arm was higher than that of the left, there was no significant difference between the left and right leg. And BMD of modern pentathlon athletes was lower than that of many martial arts(wrestling, ssireum, judo, etc.). In the future, not only nondominant segments of modern pentathlon athletes but also athletes in low-impact sports will need additional researches on how to improve the BMD of whole body and bone health in consideration of exercise mode and specificities.

Keywords: pentathlon athlete, BMD, BMC, lime bone, martial arts

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Topic : Athletic training and Sports Medicine

Presentation form: e-poster

### INFLUENCE OF CRANK LENGTH ON PEDALLING TECHNIQUE AND PHYSICAL PERFORMANCE OF CYCLISTS

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#### INTRODUCTION:

In cycling, very important is not only physical performance but also the correct coupling of bike settings and the athletes body dimensions. Aim of this study was to analyse the influence of crank length on pedalling technique and physical performance of cyclists.

#### METHODS:

In study participated 15 cyclists (6 female, 9 male) on different sport levels. After measurement of 6 dimensions: height, feet size, inseam height, torso height, arm length and shoulder width, individual bike setup was calculated using dedicated software (bikefitting.com, Shimano Dynamic Lab, Netherlands). Afterwards, calculated setup was copied on pedalling analyser (bikefitting.com, Shimano Dynamic Lab, Netherlands) and all participants performed three pedalling analysis tests (PA), according to Shimano Dynamic Lab protocol, with different crank lengths: 170mm, 172.5mm and 175mm. Based on the results of effective force, 3D effective force ratio and brake force, we chose suitable crank length for each cyclist. If selected crank length was the same as current one, we took the crank length with PA results most similar to current one. In next step, athletes performed two incremental cycling test to measure 2mmol/l (LT2) and 4mmol/l (LT4) lactate

threshold power, with different crank lengths: current and selected one. A Wilcoxon signed-rank test was performed to detect differences between measurements of lactate threshold power in those two tests, statistical level of  $p < 0.05$  was accepted.

#### RESULTS:

For eight cyclists results of PA point to the possibility of changing crank length in comparison to current length, used by sportsmen. For the next four persons results of PA were better in reference to their current crank settings, and in the remaining three cyclists results of PA were similar for two crank lengths, selected and current. In most of the subjects, difference between selected and current crank length was 2.5mm, only for two athletes was 5.0mm. Results of incremental cycling test show improvement of measured lactate threshold power values at the new crank length in 5 cyclists, in 2 subjects there were no significant changes, and in 6 athletes better results were at the current crank length. In case of two cyclists there were improvement for LT2 power, and deterioration for LT4 power. The mean change values for improvements were 6.7 +/- 3.6% and 5.5 +/- 1.5%, for LT2 and LT4 power respectively, and for deterioration was 15.2 +/- 12.0% and 8.3 +/- 5.1%, for LT2 and LT4 power respectively.

#### CONCLUSION:

Properly selected crank length could have significant influence on performance in cyclists. During selection its worthy to take into consideration the results of professional pedalling analysis, but it should be verified. It cannot be excluded, that results of incremental cycling tests for selected crank length could be better, if the cyclists had have time to used to it. The study was financially supported by Ministry of Sport in Poland (grant no.: 2019/0546/0101/Udot/70/DSW).

### EFFECTS OF SHORT-LASTING HIGH-INTENSITY INTERVAL TRAINING UNDER HYPOBARIC HYPOXIC CONDITIONS ON BLOOD PRESSURE AND ARTERIAL STIFFNESS

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#### INTRODUCTION:

We have reported that moderate-intensity endurance training under hypoxic conditions improves risk factors of metabolic syndrome over the last decade (Ogita 2013, Ogita 2017). Several studies have also demonstrated that high-intensity interval training has positive effects on metabolic disease. Taken together, we hypothesized that high-intensity interval training under hypoxic conditions would improve metabolic risk factors even more effectively. The present study therefore examined the effects of short-lasting high-intensity interval exercise (SHIIE) under hypobaric hypoxic conditions on blood pressure and arterial stiffness.

#### METHODS:

Twenty healthy male subjects (mean age, 22±1 years) who were matched for baseline measurements were randomized into two groups: a normoxic group (NORM; n=10); and a hypoxic group (HYPO; n=10). Both groups underwent ten 15s bout at 175%VO<sub>2</sub>max with 10s active rest at 50%VO<sub>2</sub>max between each bout twice a day, 4 days/week, for 4 weeks. The HYPO group performed the training under hypobaric hypoxic conditions corresponding to 2500m above sea level. Before and after the training, systolic (SBP), diastolic (DBP) and mean blood pressure (MBP) were determined at rest and during cycling exercise at 50%VO<sub>2</sub>max. Also, arterial stiffness was assessed by cardio ankle vascular index (CAVI).

#### RESULTS:

After the 4 weeks of training, no significant changes were observed in all variables in NORM. In HYPO, on the other hand, significant decreases in DBP and MBP were found not only at rest but also during moderate exercise. In addition, CAVI also decreased significantly.

#### CONCLUSION:

Our results demonstrated that SHIIE under hypobaric hypoxic conditions, used in this study, induces improvements of blood pressure and arterial stiffness more effectively, when compared to that performed under a normoxic condition.

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### EFFECTS OF WATER EXERCISE ON URINE VOLUME DURING THE FOLLICULAR PHASE

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#### INTRODUCTION:

Previous studies demonstrated that due to the responses of the physical characterization in water differed from those on land. The purpose of this study was to investigate the relationship of in water exercise to urine volume, subjective micturition, heart rate, and rating of perceived exertion ( RPE ) during water exercise.

#### METHODS:

Six healthy female subjects (age: 21.5 ± 0.5 years, weight: 58.5 ± 2.3 kg, height: 162.3 ± 3.5 cm) volunteered for this study. Each subject signed an informed consent form. All the study procedures were approved by the Ethics Committee of the Kawasaki University of Medical Welfare. We have no COI with regard to this study. This study comprised two experimental conditions: the Land trial and the Water trial. The water level was set to the xiphoid. Subjects participated in both conditions on different days. Measurement items were urine volume, subjective micturition, heart rate, and RPE. The water temperature was 30°C. Both conditions began with 30 minutes in a sitting posture on land. Then, for the next 30 minutes, the water trial performed water exercise while the land trail performed exercise. Finally, for the last 30 minutes, both conditions were back on land in a sitting posture.

#### RESULTS:

Urine volume after immersion in the water trail was higher than that of land trial ( $p < 0.05$ ). Subjective micturition after immersion in the water trail was higher than that of land trial ( $p < 0.05$ ). No significant differences were found in heart rate and RPE between the water trail and the land trail.

#### CONCLUSION:

Venous return increases in water and urine formation rises, and the diuretic effect then increases. Previous studies demonstrated that responses to physical characterizations in water differed from those on land. 1) Urine volume and subjective micturition increase through immersion in water. 2) Urine volume increases athletic strength during exercise more in water than on land.

### ACUTE EFFECTS OF HIGH-LEVEL ORTHOSTATIC STRESS ON CARDIAC AUTONOMIC ACTIVITY AND ARTERIAL-CARDIAC BAROREFLEX FUNCTION

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#### INTRODUCTION:

Autonomic nervous system and baroreflex function play an important role for regulation of blood pressure and thus preservation of orthostatic tolerance. It has been reported that chronic exposure to hypergravity enhances baroreflex function, while chronic exposure to microgravity impairs it in the field of space medicine. However, it is still unknown whether acute exposure to high level orthostatic stress would affect the autonomic nervous system and baroreflex function. The purpose of the present study was to evaluate the effects of orthostatic stress up to pre-syncope on cardiac autonomic activity and arterial-cardiac baroreflex function in healthy sedentary individuals

#### METHODS:

Ten healthy young men were enrolled. The graded lower body negative pressure (LBNP) test was performed. LBNP applies negative pressure only to the lower body by vacuuming air from the sealed cylinder, and gradually increasing the negative pressure load to -15, -30 and -40 mmHg every 5 minutes and thereafter adding -10 mmHg every 3 minutes. The test was terminated when each subject meets the criteria of pre-syncope (SBP<80mmHg or symptoms plus SBP<90mmHg). During the experiment, R-R interval (RR) was continuously monitored with a three-lead ECG and volume clamp method (Finometer, FMS) was used to continuously measure finger arterial blood pressure. Before and after the graded LBNP test, the resting heart rate and blood pressures were measured for 5 minutes with controlled breathing at 0.2 Hz. The spectral analysis for RR and SBP variability was used to evaluate autonomic activity and transfer function analysis between SBP and RR was used to evaluate baroreflex function. High-frequency (HF) power of RR and SBP variabilities in the range of 0.15–0.25 Hz and low-frequency (LF) power in the range of 0.05–0.15 Hz were calculated from the integration of the autospectra. The transfer gain, phase, and coherence between SBP and RR were estimated in HF and LF ranges.

#### RESULTS:

After the graded LBNP, heart rate decreased from 60 to 58 bpm ( $P<0.05$  paired t-test), DBP and MBP tended to increase from 43 to 60 mmHg ( $P=0.08$ ) and from 64 mmHg to 77 mmHg ( $P=0.08$ ), respectively while SBP did not change. There was no significant difference in RR variability and SBP variability in both HF and LF ranges. The coherence is 0.5 or more in both HF and LF ranges. LF Gain increased ( $P<0.001$ ), while HF gain did not change. There was no significant difference in phase.

#### CONCLUSION:

Our findings indicate that high-level orthostatic stress did not acutely impact on the cardiac autonomic activity, while heart rate decreased. Interestingly, the high-level orthostatic stress may acutely enhance arterial-cardiac baroreflex function, suggesting the training effects against the orthostasis.

### INFLUENCE OF EXERCISE INTENSITY ON THE CORTISOL AWAKENING RESPONSE

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#### INTRODUCTION:

Salivary cortisol awakening response (CAR) is regarded as an index of chronic stress that reflects the activity of hypothalamic-pituitary-adrenal axis. The influences of exercise intensity on the cortisol awakening response was experimentally investigated.

#### METHODS:

The participants were male undergraduates in a physical education university who had continued their competition within the last 6 months ( $N = 10$ ; mean age:  $21.9 \pm 0.5$  years, mean height:  $175.0 \pm 4.6$  cm, mean weight:  $78.2 \pm 10.9$  kg, BMI:  $25.5 \pm 3.2$ ). They measured their maximum oxygen intake ( $VO_{2max}$ ) when performing incremental exercise on an electrically braked cycle ergometer until exhaustion. Then, they completed four experimental sessions based on a previously developed experimental protocol (VanBruggen et al., 2011) on each day. The protocol included (1) resting session in the sitting position, (2) 40%, (3) 60%, and (4) 80% of  $VO_{2max}$  for 20 min. In each session, they collected saliva samples (Sampling at awakening, 15 min, and 30 min after awakening for CAR assessment) and also recorded their subjective fatigue and degree of muscle pain using the visual analogue scale (VAS), and psychological condition using the short form of the Profile of Moods States 2 (POMS2-S) across 7-time points (a) before and (b) immediately after the experimental sessions, (c) 10 min, (d) 20 min, and (e) 30 min after the sessions, on the night after the sessions at 9:00 pm, and 11:00 pm, and during awakening the day after the sessions. CAR was analyzed for the amount of increase (CAR increase: CARi), the rate of increase (CAR%), the area under the curve (the area under the curve with respect to Ground: AUCG; the area under the curve with respect to Increase: AUCI), and POMS2-S used the data of total mood disturbance (TMD) point. Saliva samples were analyzed for salivary cortisol concentrations using enzyme-linked immunosorbent assay (ELISA). Most measures were analyzed by a two-way repeated measure ANOVA, whereas the difference between experimental sessions in CARi, CAR%, AUCG, AUCI, VAS, and the TMD point during awakening was analyzed by a one-way repeated measure ANOVA.

#### RESULTS:

The results showed that salivary cortisol concentration increased after an exercise session at 80% of  $VO_{2max}$  intensity, and recovered on the night after the session. Nevertheless, CARi and AUCI on the day after an exercise session at 80% of  $VO_{2max}$  were higher than the resting session. However, there were no significant differences in subjective assessments at awakening.

#### CONCLUSION:

These results suggest that CARi and AUCI on the day after high-intensity exercise show a primary chronic stress state without having any awareness of physical fatigue.

## VITAMIN B1 DERIVATIVE STIMULATES BRAIN DOPAMINERGIC NEURONS, POTENTIALLY INCREASING VOLUNTARY PHYSICAL ACTIVITY

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### INTRODUCTION:

Better health in body and mind is based on a physically active lifestyle, and it is urgent that supporting agents for such a lifestyle be developed. We have found a useful nutritional supplement that enhances locomotor activity; the vitamin B1 derivative thiamine tetrahydrofurfuryl disulfide (TTFD) increases the dopamine (DA) released in the prefrontal cortex, which results in increased locomotor activity via the D1 receptor [1]. Thus, the mesocortical/limbic dopaminergic (DAergic) neurons projecting from the ventral tegmental area (VTA) are thought to be activated. Here we performed immunocytochemical studies to count the number of TH/Fos double positive cells in the VTA in order to assess where and to what extent DAergic neurons are activated in the VTA with TTFD.

### METHODS:

Male Wistar rats (11 weeks old) were used. A guide cannula was placed in the rats medial prefrontal cortex (mPFC) and the rats were acclimated for one week to a voluntary physical activity monitor. After the animals fasted for 2 hours, i.p. injections with TTFD (50 mg/kg) or saline were carried out. The brains were removed 100 minutes later and brain sections were prepared for immunohistochemical analysis. The activity of the VTA nerve cells was evaluated through the number of TH/Fos double positive cells.

### RESULTS:

TTFD injection increased the number of TH/Fos double positive cells in the ventral lateral side of the VTA. In particular, positive cells increased remarkably in the ventral and lateral parts of the VTA.

### CONCLUSION:

In the present study, TTFD injection resulted in activated DAergic neurons in the ventrolateral part of the VTA. Since DAergic neurons in this area are known to be the origin of the mesocortical/limbic system [2], their activation might mediate TTFD-enhanced physical activity. TTFD can be expected as a next-generation supplement strategy to enhance physically active behavior in the future.

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## EFFECT OF AEROBIC EXERCISE AND RESISTANCE EXERCISE ON SKELETAL MUSCLE DURING HEAD-DOWN-TILT BED REST

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### INTRODUCTION:

Exposure to microgravity causes functional and structural impairment of skeletal muscle, an integrated countermeasure is needed that addresses musculoskeletal. Aerobic exercise and supplemental resistance strength exercise may achieve these goals.

### METHODS:

Twenty-eight healthy volunteers completed 7 weeks of head-down-tilt bed rest (HDBR): Twenty-one volunteers attended 3 different exercises 4 days/wk: aerobic exercise, resistance exercise, aerobic and resistance exercise. 7 remained sedentary. Aerobic exercise consisted of 80%VO<sub>2</sub>max running, strength training consisted of 4 different movements performed between 10 and 12 repetitions per set. Aerobic and resistance exercise consisted of both running and strength training. Measurements Before and after HDBR muscle circumference, muscle cross-sectional area, and maximal voluntary isometric contraction (MVIC) were measured.

### RESULTS:

HDBR led to decreased muscle circumference (thigh and leg,  $P < 0.01$ ). It also led to decreased muscle cross-sectional area (soleus:  $-34\% \pm 7\%$ ,  $P < 0.05$ , gastrocnemius:  $-23\% \pm 10\%$ ,  $P < 0.05$ ). Knee flexor, plantar flexor and elbow flexor strength decreased in control group (Knee flexor:  $-23\% \pm 8\%$ ,  $P < 0.05$ ; plantar flexor:  $-28\% \pm 14\%$ ,  $P < 0.05$ ; elbow flexor:  $-16\% \pm 5\%$ ,  $P < 0.01$ ). Compared with the control group, aerobic exercise plus resistance exercise can reduce the descend range of rectus femoris muscle cross-sectional area ( $-9\% \pm 5\%$  VS  $15\% \pm 15\%$ ,  $P < 0.05$ ). In the meantime, it can reduce the descend range of strength in knee flexor ( $-23\% \pm 8\%$  VS  $27\% \pm 29\%$ ,  $P < 0.05$ ;  $-23\% \pm 8\%$  VS  $13\% \pm 16\%$ ,  $P < 0.05$ ) and strength in plantar flexor ( $-28\% \pm 14\%$  VS  $27\% \pm 19\%$ ,  $P < 0.05$ ;  $-28\% \pm 14\%$  VS  $19\% \pm 21\%$ ,  $P < 0.01$ ).

### CONCLUSION:

Aerobic exercise and supplemental resistive strength exercise effectively preserved skeletal muscle function and structure, it also reversed the negative impact of HDBR. Aerobic exercise plus strength training could be a primary component of exercise prescriptions for astronauts or patients suffering from severe deconditioning.

## PULSE WAVE VELOCITY AND PULSE WAVE ANALYSIS OF ELITE-LEVEL AQUATIC ATHLETES: FINDINGS FROM THE SWIMMERS HEART PROJECT

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### INTRODUCTION:

It is well established that aerobic exercise induces beneficial effects on cardiovascular health, due in part to vascular remodelling. Previous investigations have shown that individuals who regularly participate in certain activities can demonstrate sport-dependent vascular adaptations. The vascular phenotype of elite-level aquatic athletes has not been examined, but in sub-elite swimmers a divergent vascular profile distinguishes them from land-based athletes of similar caliber. Whether these adaptations in aquatic athletes occur due to training types, and/or training volumes is unknown. Therefore, the present study examined central artery stiffness and performed brachial artery pulse wave analysis in elite-level FINA swimmers (SW), open-water swimmers (OW), and water polo players (WP).

### METHODS:

68 male (9 OW, 41 SW, 18 WP) and 49 female (11 OW, 26 SW, 12 WP) elite aquatic sport athletes competing at the 18th FINA World Championships in Gwangju, South Korea, underwent measurements of brachial artery blood pressure, carotid-femoral pulse wave velocity (cfPWV), and brachial artery pulse wave analysis. Swim training volume was assessed through survey and was quantified as swimming kilometres per week.

**RESULTS:**

Male OW and SW completed more km/week (OW: 59.1±28.4, SW: 42.3±21.5, WP: 12.1±6.8km) than male WP (both  $p < 0.0001$ ). Amongst female athletes, OW completed more km/week (OW: 60.2±29.2, SW: 36.7±20.4, WP: 9.7km) than both SW and WP (both  $p < 0.001$ ), while SW completed more than WP ( $p < 0.01$ ). There were no differences in either systolic (Male; OW: 119±14, SW: 116±10, WP: 121±11 mmHg;  $p=0.3$ ; Female; OW: 106±9, SW: 111±9, WP: 110±9 mmHg;  $p=0.2$ ) or diastolic (Male ; OW: 79±10, SW: 77±8, WP: 75±10 mmHg;  $p=0.6$ ; Female ; OW: 69±6, SW: 73±7, WP: 68±11 mmHg;  $p=0.2$ ) brachial blood pressure between sports. In males, cfPWV (OW: 6.5±0.8, SW: 6.0±0.6, WP: 6.8±0.9 m/s) was greater in WP compared to SW ( $p=0.001$ ), but was not different between sports amongst female athletes (OW: 5.7±1.4, SW: 5.4±0.6, WP: 5.2±0.8 m/s;  $p=0.4$ ). Augmentation index (Alx) was lowest in both male (OW: -9.7±6.6%, SW: -4.1±10.2%, WP: 2.5±11.8%) and female (OW: -13.1±10.8%, SW: 4.9±14.6%, WP: -5.5±13.6%) OW athletes, with male WP ( $p < 0.05$ ) and female SW ( $p < 0.01$ ) demonstrating significantly greater Alx than male and female OW athletes, respectively. Across all sports, Alx normalized to a heart rate of 75 beats per minute was negatively correlated with km/week in both males and females (both  $R = -0.3$ ;  $p < 0.05$ ).

**CONCLUSION:**

The present study demonstrates unique vascular phenotypes specific to athletes competing in different aquatic sports, which may arise in a dose-dependent manner with swimming volume. Future studies should employ longitudinal designs to investigate the existence of causality between swim training and vascular remodelling.

**INFLUENCE OF THE PULMONARY VASCULAR RESERVE COMPONENTS ON AEROBIC EXERCISE CAPACITY (VO<sub>2</sub>MAX)**

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**INTRODUCTION:**

Pulmonary vascular reserve as defined by the ability of the pulmonary circulation to recruit and distend at exercise to reduce pulmonary vascular resistance (PVR) and increase pulmonary capillary volume (V<sub>c</sub>) has previously been suggested to participate to influence aerobic exercise capacity (VO<sub>2</sub>max) [1,2,3]. However, the influence of the different pulmonary vascular reserve components on VO<sub>2</sub>max remains unclear.

**METHODS:**

We reviewed 287 exercise tests performed by healthy adults (from 18 to 66 years old, with different fitness levels; VO<sub>2</sub>max from 17 to 67 ml/min/kg) in our Exercise Laboratory between 2005 and 2018. Each subject underwent a stress echocardiography allowing for the estimation of PVR calculated from the exercise-induced pulmonary arterial pressure-flow relationship, resting measurements of lung diffusing capacity for nitric oxide (DLNO) and carbon monoxide (DLCO) using the single-breath double gas technique to allow calculation of V<sub>c</sub>, and an incremental cardiopulmonary exercise test on a cyclo-ergometer for the evaluation of VO<sub>2</sub>max and the equivalent for CO<sub>2</sub> (VE/VCO<sub>2</sub>) at the first ventilatory threshold (VT).

**RESULTS:**

By univariate linear regression Vo<sub>2</sub>max corrected for body weight was associated with resting mean pulmonary artery pressure ( $R = 0.15, p < 0.05$ ), PVR, DLNO, DLCO, V<sub>c</sub> and VE/VCO<sub>2</sub> at VT (respectively  $R = -0.26, R = 0.43, R = 0.52, R = 0.49, R = -0.48$ ; all  $p < 0.0001$ ). By multivariable analysis, Vo<sub>2</sub>max was only associated with VE/VCO<sub>2</sub> at VT ( $p < 0.01$ ) and V<sub>c</sub> ( $p < 0.0001$ ), adjusted R<sup>2</sup> of the model: 0.38.

A factor analysis will be used to graphically describe the variability among those correlated pulmonary vascular reserve components.

**CONCLUSION:**

The present results suggest that pulmonary vascular reserve, defined by a combination of decreased PVR and increased V<sub>c</sub> and diffusion capacity allows for superior aerobic exercise capacity at a lower ventilatory cost. Among the pulmonary vascular reserve components, a higher pulmonary capillary bed and a lower ventilatory cost are independent predictors of a high VO<sub>2</sub>max.

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**CARDIORESPIRATORY PERFORMANCE OF ~70 YEARS OLD ENDURANCE ATHLETES AT MAXIMAL EXERCISE POWER**

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**INTRODUCTION:**

It has been shown that intensive exercise training increases cardiorespiratory (CR) output to high levels, especially in a younger age. Less is known, whether or not, the increased levels of CR output can be maintained in older age (~70 years of age). Thus the purpose of this study was to assess the differences in the CR output at anaerobic threshold and maximal exercise, obtained in senior (SA) and young athletes (YA) during maximal incremental exercise. On the basis of previous studies, we hypothesized that compared to young athletes the maximal exercise power will be reduced in senior athletes due to reduced cardiorespiratory variables.

**METHODS:**

Senior (age: 68.5±9.3 years, n=10) and young male athletes (age: 25.9±5.9 years, n=8) performed an incremental exercise test on a treadmill ergometer and pulmonary ventilation (VE), oxygen uptake (VO<sub>2</sub>), VO<sub>2</sub>max, expired carbon dioxide (VCO<sub>2</sub>), and respiratory exchange ratio (RER), breath frequency (BF, number of breath.min<sup>-1</sup>) were measured.

**RESULTS:**

There were no significant differences in the body weights between the YA and SA (72.8 ±7.5 vs 75.8 ±7.7 kg), however, there were significant differences regarding the peak power (451.6±5 vs 172.4 ±32.2 Watt), aerobic capacity (57.9±7.5 vs 40.1±8.6 ml.kg<sup>-1</sup>.min<sup>-1</sup>), maximal heart rate (190.9±9.2 vs 158.5±9.1 beats.min<sup>-1</sup>), and % VO<sub>2</sub>max at ventilatory thresholds (93.2±4.3 vs 79.3 ±9.9 %). The power output at anaerobic threshold was also higher (392±48 vs 151±23 Watt) in the YA compared to SA, explaining the significant difference in performance between these groups. The BF also declined with age (44±6 vs 37±6 number of breath.min<sup>-1</sup>).

**CONCLUSION:**



These data suggest that - compared to young athletes – the level of exercise performance is substantially less in senior athletes (~70 years of age), which is most likely due to declining in their cardiorespiratory functions, such as reduced cardiac output and gas exchange, due to aging cardiac and respiratory systems. Thus the so-called senior athlete model' provides an important means to elucidate the underlying mechanisms of declining exercise performance with aging.

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### **CEREBRAL BLOOD VOLUME AND CEREBRAL OXYGEN EXCHANGE IN THE MOTOR-RELATED AREA DURING AND AFTER A 20-MIN MODERATE-INTENSITY CYCLING EXERCISE**

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#### **INTRODUCTION:**

A single bout of exercise can increase cerebral blood flow in the motor-related area and can change brain connectivity. Moreover, a moderate-intensity exercise (MIE) improves cortical oxygenation in the prefrontal cortex and motor-related area, especially in the supplementary motor area (SMA) and primary motor cortex (M1). However, changes in cerebral oxygen exchange (COE) that indicate hypoxic or hyperoxic changes in the SMA and M1 during and after a 20-min MIE are unknown. Studying these changes during and after exercise can help in the understanding of the effects of exercise in the motor-related cortical area. This study aimed to assess cerebral blood volume (CBV) and COE changes in the SMA and M1 during and after a 20-min MIE.

#### **METHODS:**

Twelve healthy and young volunteers participated in this study. Each participant received oral and written descriptions of the objectives, measurement techniques, and risks and benefits of the investigation. All participants consented to participate in the study. After a cardio-pulmonary exercise test with incremental loading, corresponding to 20 Watts/min, after 4 min of rest and 4 min of warming up, the participants performed a cycle ergometer exercise on a separate day. After a 3-min rest, exercise was initiated at workloads corresponding to 50% of the peak oxygen consumption for 20 min, followed by a 15-min rest period on the cycle ergometer. Oxygenated and deoxygenated haemoglobin levels in the SMA and M1 were measured using a near-infrared spectrometry system. The sampling rate was set at 7.7 Hz, and data were averaged every 1 min. Based on previous studies, we calculated the CBV and COE as follows:  $CBV = (O_2Hb + HHb) / 2^{0.5}$  and  $COE = (HHb - O_2Hb) / 2^{0.5}$ . A positive COE value indicates hypoxic change compared to the pre-exercise rest status, while a negative value indicates hyperoxic change. To compare changes in CBV and COE, analysis of variance was used and significant was set at  $p < 0.05$ .

#### **RESULTS:**

The CBV significantly increased during the 9–20-min period during the 20-min MIE and persisted through the 15-min post-exercise rest period in the SMA and M1 ( $p < 0.05$ ). Although the COE in the M1 did not change significantly, that in the SMA significantly decreased during the 12–15-min period during the 20-min MIE ( $p < 0.05$ ).

#### **CONCLUSION:**

The CBV increased from the middle phase of the MIE to more than 10 min after the MIE in the SMA and M1. The COE decreased only in the SMA.

### **EFFECTS OF DIFFERENT INTENSITIES AND DURATIONS OF AEROBIC EXERCISE TRAINING ON ARTERIAL STIFFNESS**

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#### **INTRODUCTION:**

In the present study, we investigated the effects of regular aerobic training with different intensities and durations on new indices of arterial stiffness measured via an upper-arm oscillometric device.

#### **METHODS:**

We gathered data from 41 middle-aged and older people (age  $65.0 \pm 11.7$  years). Participants were randomly divided into five groups: (1) 15 minutes of low intensity aerobic training ( $n = 10$ ); (2) 30 minutes of low intensity training ( $n = 7$ ); (3) 15 minutes of moderate intensity training ( $n = 9$ ); (4) 30 minutes of moderate intensity training ( $n = 8$ ), and (5) a non-training group ( $n = 7$ ). Training was conducted for 8 weeks, 3 times per week. Arterial pulse wave index, arterial pressure volume index, brachial-ankle and heart-brachial pulse wave velocity, cardio-ankle vascular index, brachial and ankle blood pressure, heart rate and peak oxygen uptake were measured before and after the intervention.

#### **RESULTS:**

All indicators of arterial stiffness and brachial and ankle blood pressure in the exercise groups were significantly lower after vs. before the intervention. peak oxygen uptake did not differ before vs. after the intervention.

#### **CONCLUSION:**

The present findings indicate that regardless of the intensity or duration of aerobic exercise, regular aerobic exercise may be important in reducing arterial stiffness.

### **EXAMINATION OF PLASMA VISFATIN CONCENTRATION UPON EXTREME PHYSICAL AND MENTAL LOAD IN HUNGARIAN ATHLETES**

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UNIVERSITY OF PÉCS

#### **INTRODUCTION:**

Visfatin is a cytokine that is mainly synthesized in visceral fat but it can be found in the liver, bone marrow and muscles, as well. It is an adipokine associated with obesity, involved in inflammatory phenomena and insulin secretion. Visfatin reduces insulin resistance and the apoptosis of activated neutrophils. According the literature visfatin might play a role in physical activity. The aim of the research is to examine how the concentration of plasma visfatin changes in athletes as a result of physical and mental stress.

#### **METHODS:**

The physical load was a vita maxima type treadmill test. The protocol included fixed incline and steadily rising speed. To stimulate mental stress, the athletes were locked in a tactical room where they participated in a military combat stimulation. We recorded the changes in

blood pressure (BP), heart rate (HR), respiratory parameters (VO<sub>2</sub> max), and lactate concentration in 27 athletes (mean age: 27 years) during physical and mental exercise. Blood samples were taken at three different times: before the examination at test (baseline), at maximum load (peak) and 30 minutes after peak load (recovery). Plasma visfatin (VF: Elabscience) was analyzed by ELISA.

**RESULTS:**

Systolic blood pressure measured at three different times was: 141 ± 10 mmHg, 178 ± 17 mmHg, 128 ± 10 mmHg, respectively. Diastolic blood pressure measured at three different times was: 81 ± 8 mmHg, 80 ± 10 mmHg, 71 ± 7 mmHg, respectively. The heart rate measured at three different times was: 72 ± 14 beats/min, 189 ± 9 beats/min, 83 ± 11 beats/min, respectively. Lactate levels at peak load were significantly ( $p < 0.05$ ) increased ( $11.3 \pm 2$  mmol / L;  $p = 1.37 \times 10^{-19}$ ) compared to baseline levels ( $1.02 \pm 0.47$  mmol / L). The plasma visfatin results (baseline, peak, recovery) were divided into two groups based on the median of peak minus baseline. There was a significant difference ( $p < 0.05$ ) in the above-median group between baseline and visfatin peak levels (baseline:  $4.37 \pm 2.6$  ng/ml vs peak:  $6.74 \pm 3.5$  ng/ml,  $p = 0.000167$ ) and peak and recovery levels of visfatin (peak:  $6.74 \pm 3.5$  ng/ml vs  $4.42 \pm 3.28$  ng/ml,  $p = 8.3729 \times 10^{-6}$ ). The other group was a significant difference ( $p < 0.05$ ) between peak and recovery levels of visfatin (peak:  $3.82 \pm 2.9$  ng/ml vs  $2.79 \pm 2.19$  ng/ml,  $p = 0.00400018$ ). Visfatin levels upon extreme mental stress remained unchanged.

**CONCLUSION:**

Circulatory, respiratory and metabolic parameters of the subjects increased during the spiroergometric loading to total exhaustion. Serum visfatin levels were elevated in the above-median group significantly. The possible role of visfatin in the metabolic adaptation to acute physical stress needs further investigation.

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## PHYSIOTHERAPY

### ACTLIFE PROTOCOL FOR OSTEOPOROTIC WOMEN: PRELIMINARY RESULTS AT 6 MONTHS

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**INTRODUCTION:**

Osteoporosis (OP) is characterized by a reduced bone mass, that is accompanied by an increased risk of fracture with consequent pain, decreased physical, social, and functional capacity. Therefore, the impaired postural alignment and the reduced mobility and flexibility of the spine limit the use of the normal motor strategies, important features to reduce the risk of falling. The aim of the study is to evaluate the range of motion (ROM) and joint mobility before and after 22-weeks exercise protocol (ACTLIFE) for women with post-menopausal OP.

**METHODS:**

21 sedentary women ( $63 \pm 5$  years) with primary post-menopausal OP were recruited by Center and Metabolic Skeleton Diseases at the Rizzoli Institute Orthopaedic in Bologna. Subjects with vertebral fracture were included. ACTLIFE protocol, aimed at improving joint mobility, muscle force, balance, motor coordination and endurance, was performed by the subjects twice a week for 22 weeks. The subjects were directly followed by the trainers, every 6 weeks the program was changed. The ROM of knee, hip and shoulder and the mobility of low back by sit and reach test were evaluated before and after the program.

**RESULTS:**

After 6 months of intervention, shoulders ROM significantly improved from  $40.4 \pm 36$  cm to  $29.7 \pm 33$  cm ( $p < 0.05$ ). Sit and reach test also changed from  $0.81 \pm 8.5$  cm to  $-2 \pm 9$  cm ( $p < 0.05$ ). The hip and knee ROM showed no significant differences (hip from  $103.5^\circ \pm 6.2^\circ$  to  $104.5^\circ \pm 9.6^\circ$ , knee from  $125^\circ \pm 8.9^\circ$  to  $126^\circ \pm 7.5^\circ$ ).

**CONCLUSION:**

Shoulder joint may result often weak and not-well trained. This could explain how a specific training could induce significant improvement in ROM after 6 months. Several studies reported low back pain as one of main functional problems in OP subjects. Hence, several exercises of ACTLIFE protocol were focused on improving hamstring muscles flexibility, muscles core awareness, pelvis and lumbar spine mobility. This was reflected in great results on sit and reach test. Knee and hip ROM at the baseline were already high for all the cohort, thus no significant improvements could be found after 6 months of protocol. A further analysis after 12 months could be interesting to evaluate subjects' progresses. In future, a wider experimental group is needed to better understand the role of physical activity programs on mobility and its relationship with OP disease.

### THE EFFECT OF ICING IN SPORTS FIELD: A NARRATIVE REVIEW OF LITERATURE

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**INTRODUCTION:**

The icing is used after the surgery, the injury and the muscle fatigue after exercise.

In the sports field, the icing is used for the conditioning, for example, the pitchers use icing to shoulder during games. However, the effect of the icing in the sports field is still controversial. The purpose of current study is to investigate the effect of the icing in the sports field by narrative review.

**METHODS:**

We searched on Pubmed, PEDro, and Cochrane library. The selected words were "icing", "sports", "pain". Total 11 studies were selected after removing duplication. 1 studies of them (=9.1%) does not mention about icing in all sentences. Thus, 10 studies (=90.9%) of them are using icing.

**RESULTS:**

In Clinical field

There are six studies. In these studies, the icing was treated as the part of approach for orthopedic disease or post operation protocol. There was not mentioned about single effect of the icing in both studies. One is comparing the effective approach post operation for pain relief including icing related with orthopedic diseases. They reported that icing in part of approach is effective for several orthopedic diseases patient after doing activity. Besides, cryotherapy is recommended for inclusion into rehabilitation protocols following arthroscopic knee surgery to assist with pain relief, recovery of musculoskeletal function. In another study, the icing is used for the one of the rehabilita-

tion program for relief of knee pain caused by chondromalacia patellae. In another studies, there were mentioned icing is used for relief of pain in apophysitis or plantar fasciitis. However, icing is not included in the key to successful management for it.

In sports

There are four studies. They have no common interventions and opinions. In a study of them, post-practice icing was performed and recommended. There was not mentioned about how to use. One study had the result that subjects treated with the intermittent protocol had significantly less ankle pain on activity than those using a standard 20 minute protocol. In another study, it was revealed that a rehabilitation program consisting of progressive agility, trunk stabilization exercises and icing is more effective than a program emphasizing isolated hamstring stretching, strengthening and icing in promoting return to sports and preventing injury recurrence in athletes suffering an acute hamstring strain. However, in the other study, topical cooling, a commonly used clinical intervention, seems to not improve but rather delay recovery from eccentric exercise-induced muscle damage.

CONCLUSION:

Despite the icing is used in variable sports field, current results show that there are no few logical evidence comparing the effect and risk of using icing or not using. Further research must be helpful to understand the effect of the icing and effective usage for many people and improving athlete performance.

## A MATTER OF DEGREES: A SYSTEMATIC REVIEW OF THE ERGOGENIC EFFECT OF PRE-COOLING IN HIGHLY-TRAINED ATHLETES

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INTRODUCTION:

Nowadays sport competitions take part in a great diversity of geographical areas characterized by hot environments, as the 2019 IAAF World Championships in Doha, the 2020 Olympic Games in Tokyo and the 2022 FIFA World Championship in Qatar. This situation constitutes a major challenge for trainers and medical staff due to the impact that heat causes in athletes, even compromising their health and provoking an exertional heat illness. The practice of moderate/high-intensity exercise produces large amount of energy which is eliminated as heat with an associated increase of central temperature.<sup>1</sup> Skin blood flow and sweat rate increments are crucial thermoregulatory mechanisms that favor heat loss,<sup>2</sup> although when environmental conditions are extreme this adjustments are disturbed and cannot avoid the elevation of core body temperature.<sup>3</sup> In this regard, hyperthermia is proved to reduce physical and athletic performance,<sup>4,5</sup> altering cardiovascular function and leading to both peripheral and central fatigue.<sup>6</sup> Therefore, sport scientists has focused to find cooling techniques to reduce central temperature and delay the onset of fatigue.<sup>7</sup> Thus, athletes can implement cooling before competition to facilitate heat dissipation and increase heat storage capacity, prolonging the time in which exercise intensity can be maintained before reach a critical top limit.<sup>2,8</sup>

Several reviews have approached this topic,<sup>7,9,10</sup> but no systematic reviews have been carried out since 2013.<sup>11</sup> Consequently, the purpose of this systematic review was to update and summarize the current scientific evidence in relation to the effectiveness of pre-cooling strategies in highly-trained athletes exercising/competing in high temperature and humidity environments.

METHODS:

PubMed/MEDLINE, EMBASE, Web of Science, CENTRAL, Scopus, and SPORTDiscus databases were searched from inception to December 2019. Studies were included if they fulfilled the following inclusion criteria: 1) cooling intervention applied before exercise; 2) the existence of a control condition (without cooling intervention) through a randomized crossover design; 3) ambient temperature  $\geq 30^{\circ}\text{C}$ ; 4) highly-trained athletes ( $>55$  mL/kg/min of maximal oxygen consumption [VO<sub>2</sub>max], or clearly stated in the text in case this value was not mentioned); 5) athletes not acclimatized to heat; and 6) measurement of sports performance. Two independent reviewers extracted the data from the included studies. The main outcome measurements were total distance covered, power output, completion time, time to exhaustion and work.

RESULTS:

The searched reported 26 articles. Pre-cooling techniques can be external (exposure to ice water, cold packs or cooling clothes), internal (intake of cold water or ice) or mixed. Cooling prior to exercise concluded increases in distance covered (1.5%-13.1%), mean power output (0.9%-6.9%), time to exhaustion (19%-31.9%), work (0.1%-8.5%) and mean peak torque (10.4%-22.6%), as well as reductions in completion time (0.6%-6.5%). Mixed strategies followed by cold water total immersion seem to be the most effective techniques, being directly related with the duration of cooling and showing the major effects in prolonged exercise protocols.

CONCLUSION:

The different pre-cooling methods are an effective alternative to increase sports performance in hot and humid environments. This improvement is associated with the body surface exposed and its sensibility, as well as the time of application, obtaining the best results in prolonged physical exercise protocols.

## MONITORING EXERCISE DURING REHABILITATION OF PATIENTS WITH ACQUIRED BRAIN INJURY

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INTRODUCTION:

Aerobic and resistance exercise are important components of rehabilitation in patients with acquired brain injury (ABI). Previous research showed that aerobic exercise is usually below recommended intensity levels<sup>(1)</sup>, but little is known regards the intensity of resistance exercise. This pilot study aimed to monitor the intensity, frequency and volume of both aerobic and resistance exercise, based on personalized markers, during rehabilitation of patients with ABI and compare these to existing guidelines.

METHODS:

Exercise was monitored in ten patients (5 males) with ABI (46  $\pm$  14 years) who participated in boot camp and/or fitness sessions. The heart rate (HR) at ventilatory threshold (VT) and respiratory compensation threshold (RCT), determined during a graded (sub)maximal exercise test, was used to categorize the intensity of aerobic exercise as low (HRRCT). The duration of these categories was compared to guidelines<sup>(2)</sup>. Intensity of resistance exercises was expressed as % of one repetition maximum (1-RM) and then compared to guidelines<sup>(3)</sup>. Finally, the number of sessions a week and duration of aerobic exercise was recorded. For resistance exercise we collected the number of sessions a week and volume of the exercises (number of sets and repetitions within a session).

**RESULTS:**

For the bootcamp training, participants (n=3) spent on average only 12±6min in moderate and 5±8 min in high intensity aerobic exercise. For the fitness training (n=8) this was even lower: 7±8 min, and 2±3 minutes, respectively. These values were below recommended durations of a minimum of 20 min but even when individual data were considered, only 3 participants came close to meeting these guidelines. Three of six participants came close to meeting the guidelines for increasing strength by performing resistance exercises at more than 50% of their 1-RM with an adequate volume. None of the participants trained frequent enough to meet the guidelines for increasing aerobic capacity or strength.

**CONCLUSION:**

Aerobic and resistance exercise during rehabilitation of patients with ABI do not meet existing guidelines for improving aerobic capacity and strength. Limited time available during rehabilitation may explain the insufficient number and duration of sessions. Use of valid (personalized) markers for exercise intensity may help to improve the exercise intensity of both aerobic and strength exercises.

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**EFFECTS OF ELECTRO ACUPUNCTURE ON MUSCLE SORENESS AND MUSCLE DAMAGE**

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**Introduction**

Excessive exercise load induces delayed onset muscle soreness (DOMS). It was shown that exercisetolerance was improved in mice activated the antioxidant stress response factor (Nrf2). In addition, increasing the levels of muscle damage markers after running were also suppressed. Thus, oxidative stress is probably involved in the endurance exercise (Oh and Komine et al., *Sci rep* . 2017).

Electro acupuncture (EA) is an operation often used for conditioning, but there are few reports showing the effect on DOMS. We reported that electrical stimulation activates Nrf2 in C2C12 and increase anti-oxidant capacity (Horie and Komine et al., *PLoS one* , 2013). Therefore, we

hypothesized that EA may increase antioxidant stress in skeletal muscle and suppress exercise-induced DOMS.

**Methods**

A total of 20 male university students were recruited for this study. After measuring the maximum voluntary contraction (MVC) of the biceps, the subjects were randomly and equally divided into the following two: control (CON) and EA groups. This experiment was conducted for 11 days. On the 7th day, all subjects performed eccentric exercise of the biceps on non-dominant arm (70% MVC) to induce DOMS. The subjects were given EA (1.5 Hz) for 15 min per every day to the dominant arm for the CON group and the non-dominant arm for the EA group, respectively. To assess muscle damage markers (CK, LDH) and an oxidative stress marker (MDA), blood samples were collected from the antecubital vein at seven times: pre-experiment, before and after exercise, from one to four days after exercise. At the same time, muscle soreness was assessed using the visual analog scale (VAS).

**Results**

Muscle soreness was significantly suppressed in the EA group on the 3rd and 4th day from exercise compared with the CON group. Similarly, stretching-induced muscle soreness tended to be lower 3rd day of the exercise and significantly lower 4th day after the exercise in the EA group than in the CON group. CK was increased in the CON group after exercise and reached a peak 4 days later.

LDH was also increased gradually as the day went on in each group, but the increase was suppressed in the EA group comparatively, and it was significantly lower than the CON group on the 4th day.

The concentration of the MDA was analyzed 3rd day after the exercise. As a result, MDA concentration in blood was significantly lower in the EA group than the CON group.

**Discussion & Conclusion**

Our finding provides evidence that EA can suppress muscle damage induced by eccentric exercise.

We considered about two possible mechanisms. One is the upregulation of antioxidant stress ability in the biceps. Another is increasing pain-removing ability due to increased blood flow due to repeated muscle contraction. EA stimulation before and after exercise restrained the exercise-induced DOMS. These results suggest that EA may be useful for not only conditioning but also keeping exercise motivation.

**COMPARING THE EFFECTS BETWEEN TAI CHI AND CONVENTIONAL EXERCISE IN ENHANCING COGNITIVE PERFORMANCE IN OLDER ADULTS WITH MILD COGNITIVE IMPAIRMENT (MCI): A PILOT RANDOMIZED CONTROLLED TRIAL**

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**INTRODUCTION:**

This study examined the effects of tai chi and conventional exercise on improving cognitive function in older adults with mild cognitive impairment (MCI) who have a higher chance of developing Alzheimer's disease.

**METHODS:**

In this three-arm, single-blinded, randomized controlled trial, Chinese adults aged  $\geq 50$  years with MCI [score of Montreal Cognitive Assessment Hong Kong version (MoCA-HK) below the 7th percentile of the normative data of Hong Kong] were recruited in the Hong Kong community. A total of 30 eligible individuals were randomly assigned to control group (received no intervention, n=10), conventional exercise group (received three weekly sessions of generic exercise intervention for 24 weeks, n=10), or tai chi group (received three weekly sessions of tai chi intervention for 24 weeks, n=10). The primary endpoint was the change in the score of MoCA-HK after 24-week post-randomization. The secondary endpoints included changes in trail making test and digit span after 24-week post-randomization. Data were analyzed by generalized estimated equation with baseline as covariate. Pairwise comparison was conducted by closed test procedure with Bonferroni and Holm correction. All experimental procedures received human ethics approval.

**RESULTS:**

Both tai chi group (+35% in MoCA-HK,  $P < 0.001$ ) and conventional exercise group (+27% in MoCA-HK,  $P < 0.001$ ) showed significant improvement in global cognitive function compared with the control group (+7% in MoCA-HK). The improvement was more profound in tai chi group compared with conventional exercise group ( $P = 0.024$ ). Larger reductions in trail making test B-A score were observed in tai chi (-47%,  $P < 0.001$ ) and conventional exercise (-30%,  $P = 0.001$ ) groups compared with the control group (+18%), thus indicated that both interventions improved executive function. Moreover, tai chi (-33%,  $P < 0.001$ ) and conventional exercise (-8%,  $P = 0.001$ ) groups showed significantly larger reductions in trail making test B/A ratio compared to the control group (+22%), which is indicative of both interventions improved cognitive flexibility. Notably, tai chi training induced a more robust improvement than conventional exercise training in trail making test B/A ratio ( $P = 0.025$ ). Both tai chi (+8%,  $P < 0.001$ ) and conventional exercise (+18%,  $P < 0.001$ ) led to significantly larger improvements relative to control group (-15%) in forward digit span, suggesting that both interventions are beneficial to working-memory.

#### CONCLUSION:

These data demonstrated that tai chi and conventional exercise effectively improved global cognitive function, executive function, cognitive flexibility, and working memory. Tai chi induced a more profound improvement than conventional exercise in global cognitive function and cognitive flexibility.

## ANALGESIC EFFECT OF PARTICLE PRESSURE IN SPORTS INJURY TREATMENT

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#### INTRODUCTION:

INTRODUCTION: Developing effective treatment and rehabilitation strategies for sports injuries is the primary demand in sports medicine. In addition to the common procedures such as surgery and drug therapy, the acupressure patch therapy has recently attracted attention as an effective alternative to the traditional acupuncture therapy. In this study, we performed a clinical trial to verify analgesic effects of the novel acupressure patches [bumpy patches (BPs)] developed by Saito (2014) [1]. In contrast to the traditional acupressure patches that have only one metal particle, the BPs are designed to have multiple small plastic particles in order to sustain the pressure within the specific pain area.

#### METHODS:

METHODS: We recruited 30 athletes (14 to 48 years of age; 15 males and 15 females) from patients who had been in the orthopedic clinic of Seisen Clinic with pain lasting less than 6 months. The subjects provided written informed consent after the explanation of the objectives and procedures of the study. The subjects were asked to record the pain intensity before and after the BP treatment. The pain intensity was measured on the self-report by applying mechanical pressure to the pain area. The numerical rating scale (NRS) of 100-0 was used with 0 indicating no pain and 100 indicating the pain before the first treatment (baseline).

#### RESULTS:

RESULTS: Two subjects withdrew from the study for personal reasons. Subjects reported significant reduction in the NRS values after the first BP treatment [100 vs.  $30 \pm 25.8$  (mean  $\pm$  SD),  $p < 0.05$ , Welch's t-test]. Some subjects reported that the pain area moved after applying the BPs. We also observed muscle-softening effects of BPs. All subjects reported the NRS score of zero after one to six treatments.

#### CONCLUSION:

CONCLUSION: This study demonstrated the effectiveness of BP in treating sports injuries using 28 subjects. We also have treated about 300 patients with BPs, which will be included our future studies with a larger sample size.

References 1. Saito 2014, US patent # 8,827,966 B2.

## EFFECTS OF COOLING WITH ICE PACK ON STRUCTURAL CHANGES OF TIBIAL TUBEROSITY CAUSED BY DOWN-HILL TREADMILL RUNNING IN RATS

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#### INTRODUCTION:

A cooling with an ice pack is generally used for a treatment or prevention of Osgood-Schlatter disease (OSD) that is known one of the movement injuries in the growing period. However, it hadn't been cleared how the cooling after an exercise affected a structure of tibial tuberosity. On the other hand, we have already observed that a high-intensity down-hill running in growing rats caused the tibial tuberosity to protrude, and from these facts, have thought that such exercises could bring OSD-like symptoms. However, an effect of the exercise on a structure of the tibial tuberosity hasn't been studied histologically. The purpose of this study was to investigate, using the growing rats, the effect of cooling on the structural changes of the tibial tuberosity caused by the down-hill treadmill running.

#### METHODS:

Twenty-four male rats aged 7 weeks (wistar strain), were used as materials, and were divided into a running group: EX, a running and cooling group: RC, and a control group: CO. EX and RC performed the down-hill running at an inclination angle of  $-15^\circ$  and a speed of 17 m/min for 1 hour/day and 5 days/week for 3 weeks. In addition, the tibial tuberosity in RC was cooled for 20 minutes/time using an ice pack (0.3 to  $1.3^\circ\text{C}$ ) under anesthesia, after completion of each running exercise. Each group, after the end of the experimental period, was euthanized and the tibia was excised after confirming the death, various specimens were prepared and were observed morphologically.

#### RESULTS:

The tibial tuberosity of EX was remarkably prominent than RC and CO, but the extent of protrusion of RC and CO was similar. The ligament fibers were more densely embedded in EX and RC than in CO. The superficial layer was calcified in all groups, and RC and CO were calcified up to the deeper portion than EX, but the extent of uncalcification was wide in the deep layer of EX. Type II collagen fibers were observed at the deep layer of EX by an immunostaining method, but they weren't almost seen in RC and CO. Many large chondrocytes existed in that layer of EX, but those cells of RC and CO were small.

#### CONCLUSION:

Thus, in RC and CO, the tibial tuberosity was calcified to the wide extent in the state where the fibers of the patellar ligament were embedded, but type II collagen fibers were present at the same region of EX, that is, cartilage-like structures remained yet. Furthermore, many large chondrocytes existed in that layer of EX, but those structure weren't observed in RC and CO. Therefore, it seems that the cooling has an effect of inhibiting the structural change of the tibial tuberosity caused by the down-hill running. It was speculated that the protrusion of the tibial tuberosity accompanied with the downhill running was caused by the structural changes that many large chondrocytes appeared at the deep layer of that portion and those changes could be inhibited with the cooling.

**THE EFFECT OF HIROSHIMA GENKI EXERCISE ON THE HALLUX VALGUS ANGLE.**

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**INTRODUCTION:**

Hallux valgus is a common foot deformity, presenting in 35% of women over 65 years of age [1], and presents a significant individual and public health burden because of its association with foot pain, osteoarthritis at the first metatarsophalangeal joint, impaired gait patterns, poor coordinated stability and an increased risk of falls in older adults [1]. Because a previous study recommended exercise training for this treatment [2], we developed the foot functional training called by "Hiroshima GENKI Exercise" and investigated the effect of the Hiroshima GENKI Exercise on the foot structure in Japanese older adults.

**METHODS:**

This study was a 10-month randomized controlled trial. 22 Japanese older adults aged 65 to 80 years were participated in this study. Participants were randomly allocated to either the intervention group (n=11) or the control group (n=11). The intervention group underwent the Hiroshima GENKI Exercise for 60 min once a week over the course of 10 months. This training was performed through supervised sessions (group training) and was designed to apply mechanical loads and vibration to the bones of the foot. The foot length, foot circumference, foot width, heel width, angles of the first and fifth metatarsophalangeal joints (MTPJ), foot height, arch height and arch height ratio were measured before and after the 10-month training by using a three-dimensional foot digitizer.

**RESULTS:**

Physical characteristics and all measures before the 10-month training did not differ between groups. The 10-month training did not improve foot length, foot circumference, foot width, heel width, first toe side angle, angle of the fifth MTPJ, foot height, arch height, arch height ratio. However, the angle of the first MTPJ was improved by the 10-month training, and it after the 10-month training was significantly higher in the intervention group than in the control group (before; intervention  $10.0 \pm 9.0^\circ$ , control  $8.8 \pm 4.5^\circ$ , after; intervention  $5.2 \pm 7.2^\circ$ , control  $11.8 \pm 9.7^\circ$ ,  $p < 0.05$ ).

**CONCLUSION:**

The present study demonstrated an improvement of the angle of the first MTPJ after the 10-month Hiroshima GENKI Exercise. Participants in the intervention group had  $10^\circ$  of the first MTPJ angle (hallux valgus) before the 10-month training, but Hiroshima GENKI Exercise normalized the angle of the first MTPJ. Thus, we concluded that the foot functional training called by "Hiroshima GENKI Exercise" was effective for the treatment of hallux valgus in Japanese older adults.

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**THE INFLUENCE OF RESISTANCE BAND TRAINING ON RISK FACTORS FOR VERTEBRAL FRACTURE IN POSTMENOPAUSAL WOMEN**

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**INTRODUCTION:**

Vertebral fractures contribute to kyphotic spinal deformity and cause diminished functional daily movement. Exercise may reduce osteoporotic fracture risk by reducing spinal curvature, increasing spinal extensor strength or reducing fall risk as well as by increasing bone strength. There is some evidence that resistance training increases spinal extensor strength and physical function but conventional resistance training may not be popular with postmenopausal women. Resistance band exercise may be more acceptable but there is no information on the effect of resistance band training on these outcomes. This study thus aimed to investigate whether resistance band and posture exercise can improve spinal extensor strength, thoracic kyphosis and postural sway in postmenopausal women.

**METHODS:**

Post-menopausal women aged 60 – 80 years were recruited who were healthy and not taking medication that affects bone. Participants were randomised to an exercise group or control group. The exercise group were asked to attend a supervised exercise session once a week and exercise twice weekly at home. The exercise programme involved three resistance band exercises (squat, deadlift and overhead press) as well as postural exercises (prone back extension exercise, "dead bug" and "bird-dog"). Cobb angle was determined as a measure of thoracic kyphosis from lateral spine dual-energy X-ray absorptiometry (DXA) scans. Postural sway was measured during 30s standing on a force plate, and back extensor strength was assessed using a handheld dynamometer mounted in a custom-built rig. All measurements were assessed at baseline and after 6 months.

**RESULTS:**

Forty-one participants were recruited, age (mean + SD)  $67.2 \pm 4.9$  years. 18 exercisers and 12 controls have completed the study so far. Exercisers completed an average of  $19.7 \pm 6.1$  of the prescribed 24 supervised exercise sessions and reported an average of  $39.7 \pm 7.1$  of 48 prescribed home sessions. Cobb angle changes differed significantly between groups ( $P=0.023$ ), declining from baseline to follow up in the exercise group (from  $32.3 \pm 10.1^\circ$  to  $30.8 \pm 9.4^\circ$ ) and increasing in the control group (from  $31.9 \pm 7.3$  to  $33.0 \pm 8.4^\circ$ ). Back extensor strength responses also differed between groups ( $P=0.049$ ) increasing from  $220 \pm 62$  N to  $246 \pm 41$  N in the exercise group and decreasing from  $220 \pm 50$  to  $216 \pm 42$  N in the control group. There were no significant changes in postural sway.

**CONCLUSION:**

A resistance band exercise programme reduced thoracic kyphosis and improved back extensor strength in postmenopausal women, although it did not benefit postural sway. This type of exercise may benefit some risk factors for vertebral fracture but may need to be performed alongside balance training to reduce fall risk.

## PSYCHOLOGY

### TEAM SPORTS EXPERTISE MODULATES NEURAL ACTIVITY DURING PERCEPTUAL DECISION MAKING

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#### Introduction

There is accumulating evidence to suggest that team sports expertise is associated with greater perceptual decisions. In particular, recent studies have demonstrated superior cognitive control performance in elite team sports players (e.g., football players). However, the precise mechanism underlying cognitive superiority in elite athletes remains to be described. To address this issue, we employed event-related potential (ERP) to investigate the neural mechanism underlying the difference between elite football players and non-athletes in perceptual decision-making when dealing with conflicting information.

#### Methods

Data were collected from 20 division I collegiate male football players (aged  $20.15 \pm 0.93$  years) and 20 age- and gender-matched non-athletic controls (aged  $21.45 \pm 1.39$  years) from the general student population. Participants' behavioral and electroencephalographic (EEG) data were recorded simultaneously when performing a modified go/nogo paradigm, where participants had to monitor two sources of visual features (i.e., color and shape). The go-signal for shape was X and the go-signal for color was green. The no-go signal was O, while the no-go signal color was cyan. As a result, the paradigm consisted of a double-go condition (i.e., a green X), a single-go cognition (i.e., a green O or a cyan X), and a no-go condition (i.e., a cyan O). Participants were instructed to make a response as quickly and accurately as possible if they detected either go signals for color or shape, whereas they were required to hold their responses if they detected neither go signals.

#### Results

Behavioral results showed that there were no group differences in terms of accuracy and mean reaction times across all task conditions. However, the ERP results revealed that the amplitude of midfrontal N2 changed as a function of the level of the no-go signal in the football players, with the greatest N2 for the no-go condition, intermediate for the single-go condition, and smallest for the double-go condition. In contrast, in the control group, the N2 difference was only observed when comparing no-go and double-go conditions, while no other N2 differences were found for other condition comparisons.

#### Discussion

Although the cognitive control task used in this study was not sufficiently sensitive to detect any difference between elite football players and non-athletes at the behavioral level, the ERP data suggest that team sports expertise may be related to greater ability to monitor two sources of information provide evidence indicating opposing responses. To elaborate, the players exhibited greater ability to detect the no-go signal when the go and no-go signals were presented simultaneously. Our data thus indicate that even simple perceptual decisions are influenced by extensive experience in team sports, which may be one of the potential mechanisms leading to perceptual-cognitive expertise in sports.

### MOTIVATIONAL CONTEXT AND PERFECTIONISM LITTLE ADAPTIVE IN SPORT

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#### Introduction

In the sports context, coaches play an important role in the formation of experiences of athletes, because they exercise control over many facets of their lives (Barcza-Renner et al., 2016). Two motivational theories most used in sport, and that study the social environment, are the Achievement goals theory (AGT; Ames, 1992) and the Self-determination theory (SDT; Ryan and Deci, 2000). These two theories are not conflicting or disjunctive, rather complementary (Gutiérrez and Tomás, 2018). The sports context is characterized by the value it gives to the competition, social comparison, the emphasis on winning, and public recognition of the ability shown (Ames, 1992), so it can have an influence on perfectionism. Considering that AGT and SDT are complementary and relevant to sports performance, and in an effort to improve the understanding of the nature of the multivariate relationship between social context and poorly adaptive perfectionism, this study was intended to relate motivational climates (ego climate and task climate), support for autonomy, pressure for perfection by the coach, and concern about mistakes in young athletes.

#### Methods

The sample consists of 157 athletes (87 men, and 70 women) with ages between 8 and 14 years ( $M = 12.48$ ;  $DT = 1.80$ ), to which a battery questionnaires were applied that includes all the study variables.

#### Results

The results confirmed that autonomy support is positively related to the task climate ( $r = .28$ ;  $p < .01$ ) and negatively to the ego climate ( $r = -.29$ ;  $p < .01$ ), the ego climate is it relates to the pressure for perfection on the part of the coach ( $r = .53$ ;  $p < .01$ ), and with the concern about mistakes in athletes ( $r = .32$ ;  $p < .01$ ).

#### Discussion

These results are consistent with previous studies that analyzed these variables not as a whole, if not separately. This study highlights the importance of contemplating motivational contexts as important elements in the psychological functioning of the athlete.

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## TRAIT ANXIETY, EMOTIONAL COMPETENCIES, AND SPORT INJURY: A CROSS-SECTIONAL STUDY AMONG COMPETITIVE ATHLETES

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### Abstract:

Participation in competitive sport remains a stressful situation for most athletes. In the stress and injury model of Williams and Andersen (1998), trait anxiety and emotional competencies are stable psychological predictors of sport injury. The aim of this study is to highlight the associations of trait anxiety and emotional competencies with sport injuries. We hypothesize that higher trait anxiety and lower emotional competencies would be associated with more sport injuries.

A total of 261 adults (36% women) training for competition participated in this online survey. After providing information regarding their sport practice and sport injuries (in the last 6 months), participants were invited to fill out the State-Trait Anxiety Inventory (STAI; Spielberger, 1971) in its trait version and the Profile of Emotional Competencies (PEC; Brasseur et al., 2013). Emotional competencies were identification, understanding, expression, regulation, and use of intrapersonal and interpersonal emotions. The final sample is composed of 176 athletes as 57 and 28 didn't fill out the STAI and the PEC, respectively.

Participants showed higher trait anxiety (not injured: 40.2; 1 injury: 41.5; 2 injuries: 43.5; 3 or more injuries: 48.2;  $p=0.014$ ) and lower intrapersonal emotional competencies (not injured: 3.52; 1 injury: 3.35; 2 injuries: 3.31; 3 or more injuries: 3.16;  $p=0.022$ ) when they reported more injuries. The correlation between trait anxiety and intrapersonal emotional competencies showed larger negative coefficients as the number of injuries increased for identification (not injured: -0.46; 1 injury: -0.53; 2 injuries: -0.28; 3 or more injuries: -0.67), understanding (not injured: -0.54; 1 injury: -0.53; 2 injuries: -0.65; 3 or more injuries: -0.78), and regulation (not injured: -0.63; 1 injury: -0.64; 2 injuries: -0.72; 3 or more injuries: -0.73).

The results of this cross-sectional study showed that the association between anxiety and sport injury seem to be a lowered when intrapersonal emotional competencies are higher in a sample of competitive athletes. These results highlight the importance of training emotional competencies of athletes in order to reduce the risk of injury. Prospective research designs are needed to test the causal associations of anxiety and emotional competencies with sport injury, and interventions aiming at training emotional competencies could be tested.

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## MEASURING RESILIENCE IN ATHLETES WITH PHYSICAL DISABILITIES

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### INTRODUCTION

Recent study displayed significantly lower mean resilience of athletes with a physical disability than those reported in other studies with the general population(1). This study aimed to analyze whether there are differences or/and similarities between wheelchair tennis players (WTP) and able-bodied tennis players (TP) and to investigate about the characteristics of resilience.

### METHODS

80 participants: 39 WTP and 41 TP. Several tools have been used: a personal data collection form and 6 self-report questionnaires (1: Italian Adaptation of Connor-Davidson Resilience Scale, CD-RISC; 2: Trait Sport-Confidence Inventory, TSCI; 3: Italian Adaptation of the General Self-Efficacy Scale, GSE; 4: Emotion Regulation Questionnaire, ERQ; 5: Multidimensional Scale of Perceived Social Support, MSPSS; 6: Inventory of Stressful and Traumatic Life Events, STLE). The data collected were analyzed using the SPSS 16 statistics program.

### RESULTS

The analysis of CD-RISCs showed: 18% of WTP had a level of resilience beneath 30 compared to 46% of TP; 82% of WTP had a good/excellent ability to manage stress compared to 54% of TP. Through the analysis of TSICs, no significant differences of confidence emerged between WTP and TP. GSEs showed: 78% of WTP had a self-efficacy of more than 30 compared to 64% of able-bodied players. The analysis of ERQs showed that TP controlled emotions slightly better than WTP and that WTP suppressed emotions more than TP. MSPSSs showed that TP perceived social support slightly higher than WTP. Through the analysis of STLEs, it was noted that 15% of WTP had suffered a high level of traumatic events during the life compared to 8% of TP.

### CONCLUSION

The majority of WTP of this study have a higher level of resilience than the majority of TP. The most significant result concerns the self-efficacy which was higher in WTP. Further research is needed to study any correlations between the different aspects of resilience. The strength of this study is its innovative way of analyzing the resilience through different questionnaires.

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## DEVELOPMENT OF THE STRESSOR SCALE FOR JAPANESE REFEREES

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### Introduction

Sports referees are responsible for ensuring that the competitive efforts of athletes occur within the rules of the game, and that match results are obtained fairly. Referees must continuously endure physical pressure; they should, however, also be willing to psychologically endure various stressors. As the best performance cannot be expected from athletes and coaches who are under a great deal of stress, referees are, similarly, sometimes unable to demonstrate proper performance (Reilly and Eregson, 2006). However, few studies have



focused on the sources of stress for Japanese referees. The purpose of this study, therefore, is to develop the stressor scale for Japanese referees, and to identify the sources of stress in international and national referees.

#### Methods

The population of this study was Japanese referees from the fields of baseball, football, and tennis. The average age of the 252 referees sampled was  $45.9 \pm 12.7$  years old, with years of refereeing ranging from 2 to 37 years. Over 20 per cent of the referees were internationally certified. After interviews with the referees, 27 questionnaire items were prepared to assess the referees' stressors. Examples of items included making a wrong call; verbal abuse by players, coaches or spectators; and arguing with players.

#### Results

To examine the internal consistency of the items, we calculated the correlation coefficient between the summation of item scores in the scale and the rated scores on each item. A significant correlation was obtained ( $r = .39-.78$ ) for all items, which showed internal consistency. Factor analysis (principal factor solution, promax method) was employed to identify the factor structure of questionnaire items. For refereeing stressors, 5 factors were identified from 22 items in the questionnaire and are as follows: expectation and pressure from others, interpersonal conflicts, lack of cooperation among referees, fear of judgement mistake, and family-work conflicts.

#### Discussion

The exploratory factor analysis indicated that the stressful factors for the referees could be classified into five groups. The inter-item data indicate that the most salient sources of stress for the referees were interpersonal conflicts and fear of judgement mistake. Overall, the present investigation revealed that the sampled referees experienced similar sources of stress as sport officials from previous research (Voight, 2009). The information gathered from this study also provides insight into how we can create better stress management programs for this population.

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Voight, M. (2009) Sources of stress and coping strategies of US soccer officials. *Stress and Health* 25: 91-101.

### STATE OF CHANGE BETTER PREDICTOR OF STRESS STATE TAN PSS AND WAI AMONG OFFICE WORKERS

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#### INTRODUCTION:

Physical activity (PA) has a positive impact on stress and anxiety (1). Working conditions affect the quality of life, increasing stress levels, being able to become chronic stress (2) which can affect job performance and work leave (3). Perceived Stress Scale (PSS), Work Ability Index (WAI), and State of change (TTM) have been applied to know the state of the workers in their job. Heart rate variability (HVR) is related to stress. However, it is necessary to monitor HR during, as a minimum, two days, which difficult data collection. The purpose of this study is to know which questionnaire (ICC, PSS, TTM) is more representative of stress measured by VFC in office workers to improve the measuring process.

#### METHODS:

125 office workers, which had to record their HR during two full days. Groups were set up according to test results TMM (PC, C, P&A y Ma), PSS (G1, G2 y G3) and WAI (G1, G2 y G3). Results obtained by the test were related to stress values measured by HR with Bodyguard 2 device.

#### RESULTS:

TTM test shows differences between subjects who practice PA regularly for more than six months (Ma) and do not practice PA (PC). Ma has better HVR and stress levels than the other groups, in women ( $p = 0.049$ ; ES: 0.642) and men. ( $p < 0.005$ ; ES: 2.157). Apart from that, subjects with excellent work capacity, according to WAI, are associated with better HRV, without differences between men ( $p = 0.032$ ; ES: 1.424) and women ( $p = 0.018$ ; ES: 2.158). Likewise, the relation between low-stress levels obtained through the PSS test and better HRV can be observed in men (groups 1 and 3 ( $p < 0.005$ ; ES: 2.985)) and women (groups 1 and 3 ( $p < 0.005$ ; ES: 4.321)); Finally, % stress is different between groups according to the total of hours of PA ( $p < 0.005$ ; ES: 2.794).

#### CONCLUSION:

Depending on the time stress is measured, the results may change. Our results concluded that workers who have practised PA regularly more than six months have better HRV than people who have not practised exercise. It is argued that TTM may be the best strategy to improve stress in workers because concerns stress as a changing state influenced by the PA.

### INFLUENCE OF PHYSICAL ACTIVITY IN THE QUALITY OF LIFE IN AGING.

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#### INTRODUCTION:

Physical activity is one of the aspects of lifestyle that produces major influence in the health aspects of elderly. The promotion of physical activity along life course is important to maintain physical capacity along old ages. The key to active ageing is to keep the body moving, as well as, crucially, to keep an active mind, these goals can be achieved in combination. Regular physical activity reduces total mortality risk, from cardiovascular diseases and many other causes. Sedentarism and the number of hours of physical inactivity seem to act as independent risk factors for health and longevity. Further, an active life is fun and also helps for socialization. Furthermore, the 2010 WHO Global recommendations highlight the importance of physical activity for health and quality of life during aging. Thus, physical activity has been linked to a plethora of health benefits, especially in those people particularly vulnerable. The purpose of this work is to determinate the level of physical activity in the old age (65 y or over) and how it can to interfere in the health.

#### METHODS:

One hundred fifty six old individuals, averaged 75 years old, living in Seville, Andalusia, Spain participated in this study. They were reclused in Active Participation Centres or elderly residences. Socio-demographic and lifestyle variables were collected through questionnaires and anthropometric parameters such as metabolic age, BMI, visceral fat, were obtained by bio-impedance. The International Physical Activity Questionary in its short version (IPAQ-E) was used as tool for measuring physical activity and The Assessment of Quality of Life (AQoL) for health-related Quality of Life determination.

#### RESULTS:

A MANOVA was performed with the levels of physical activity (low, moderate, high) as the independent variable and the anthropometrics measures and quality of life as dependent variables. There were significant differences between the older people with low level of physical activity and those with a high level of physical activity in the anthropometrics and health variables. Individuals practising high level of physical activity showed younger metabolic age, less index of visceral fat and lower BMI score. The health AQoL score were worse among the older people with low physical activity.

#### CONCLUSION:

Physical activity positively influences health and well-being of the elderly, both physically and psychologically. Our study suggests that a lifestyle characterized by a high level of physical activity regardless of sex during aging is the best way to maintain health during aging. This statement is reinforced by the finding of significantly lower relationships of visceral fat levels, metabolic age and BMI in individuals with a high level of physical activity compared to those with a low level of physical activity. Some exercise is better than none, while more is better than some.

### THE EFFECTS OF DANCESPORT COMPANION PARTICIPATION ON SPORTS CONFIDENCE AND EXERCISE ADHERENCE

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#### Introduction

DanceSport is a proactive type of leisure activity which can solve social & pathological problems & promote physical activities. Participating in dancesport enhances and maintains health, which generates passion and confidence (Kim, 2011) as well as improves social life along with happiness & joy. As a result, exercise adherence affects strength, stress, joy, satisfaction with life, and self-realization (Dishman, 1985). This study aims to examine the effects of dancesports club members' participation in competitions on sports confidence and exercise adherence.

#### Methods

Participants: 235 dancesport club members from Seoul and Kyunggi-do joined the research. Tools: The SSCQ by Vealey (1986) & the questionnaire by Wonbae Kim (1999) were used. Kim's questionnaire proved its validity with Korean athletes & consists of 4 factors in 5-point scale. In addition, the Korean version of the Exercise Adherence Questionnaire (EAQ) created by Corbin & Lindsey (1994) was used to check exercise adherence (Oh et al. 2000). It is composed with 3 factors in 5-point scale.

Analysis: t-test, one-way ANOVA, Standard Multiple Regression Analysis

#### Results and discussion

Sports confidence depending on the experience of participating in dancesport competitions indicates a meaningful difference in Coach's Leadership, which shows men has a higher score than women. Sports confidence according to the period of exercise demonstrates a meaningful difference in Ability Demonstration, Coach's Leadership, Social Support. Physical/Psychological Preparation shows a meaningful difference with  $p < .001$ . As a result, the longer people have exercised dancesport, the higher their confidence is. In exercise adherence depending on the experience of participating in dancesport competitions, Tendency was higher in men than women with a meaningful difference. In exercise adherence according to the period of exercise, all the Reinforcement, Tendency, and Possibility show a meaningful difference. Accordingly, the longer people have played dancesport, the higher the scores of exercise adherence are. Sports confidence was influenced by the competition experience with the explanatory power of 56.4, which indicates Coach's Leadership is negatively impacted with the  $p < .001$ . The competition experience didn't affect exercise adherence. The explanatory power is around 3.5%. The relationship between sports confidence of dancesport club members and exercise adherence has the explanatory power of 42.8%, & only Tendency displays a meaningful influence.

#### Conclusion

The longer club members have played dancesport, the more sports confidence and exercise adherence are affected positively. The experience of participating in dancesport competitions gives a positive influence on sports confidence and exercise adherence.

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### FACTORS AFFECTING THE ENJOYMENT OF COMMUNITY SPORTS CLASSES: INVESTIGATING FROM THE VIEW OF PARENTS

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Introduction: In recent years in Japan, there has been a demand for community sports clubs which can meet the diverse needs of residents as well as the development of a new community sports system. Although enjoyment is an important factor for people to continue participating in sport, few studies have considered the enjoyment factor in community sports. This is because the development of community sports clubs has been delayed due to the importance placed on single event competitive sports. The purpose of this study is to obtain basic knowledge for the factors concerning people's enjoyment of community sports classes.

Method: Parents (N=133) who participated in or spectated at community sports classes were targeted for this study. At the end of each class, the subjects were asked to describe the factors that induced enjoyment during the participation in community sports. The descriptions obtained were classified by three researchers with knowledge of community sports using the KJ method.

Results: Eighty-eight descriptions were obtained from parents, which were classified into 12 categories, such as teaching method, experience/challenge and interaction with leaders. Then the 12 categories were grouped into five groups: leader, program, interaction, achievement and emotion.

Discussion: Factors such as instruction and achievement partially overlapped with the factors that brought enjoyment during conventional physical education classes. On the other hand, factors such as interaction and program showed some differences from those of conventional sports activities. Interaction is similar to the categories of social factors, human relationships and friendship, which induced enjoyment during conventional sports activities. Interaction is, however, a keyword and presumed to be a unique factor of community sports clubs in Japan.

## MOTIVATING FACTORS FOR EXERCISE USING TOPIC MODELS AMONG COLLEGE STUDENTS

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### Introduction

The purpose of this study is to clarify and provide materials that can make inferences and predictions about exercise motivation from the developmental point of view. We analyzed the qualitative data of the motivating factors of exercise and used a topic model to reveal the reasons college students do or do not exercise.

### Method

Subjects: A total of 556 college students (433 men and 123 women) participated in the study.

Measurements: Individual factors affecting participants' exercise motivation were assessed by asking them to freely describe events or situations that they thought affected their motivation to exercise.)

Analysis method: The self-reflection descriptions obtained were analyzed according to the following procedure.

1) We performed a morphological analysis on text data using MeCab Ver0.996 (Kudo 2013). The analysis included the following parts of speech: nouns, adjectives, and verbs. Particles, auxiliary verbs, punctuation, and symbols were excluded.

2) The results obtained were saved in a database and a topic model analysis was performed using statistical analysis software R 3.6.1. The topic model analysis package used Latent Dirichlet Allocation (LDA), which assumed a Dirichlet distribution as the topic distribution method and performed Bayesian estimation using Gibbs sampling. LDA is a typical topic model involving the word generation process in a document, assuming latent variables (topics) for each word in the document, and determining the topic occurrence probability distribution for each document.

### Results and Discussion

Using topic models for "nouns, adjectives, and verbs" to analyze "self-reflection," the probability of belonging to each topic for each self-reflection (topic distribution for each self-reflection) and the probability in each topic for each word (word distribution for each topic) were estimated. Topics about exercise motivation were classified into "school life," "parent-child relationships," "companion relationships," "play experience," and "other factors." The topic "school life" comprised words like "teacher" and "club activities." Similarly, the topic "parent-child relationship" was composed of "father" and "mother." The topic "companion relationships," consisted of "friends," "seniors," and "junior." The topic "play experience" consisted of "sports" and "play," and the topic "other factors" consisted of "coach" and "club." Generating topic distributions for each self-reflection aspect revealed topic patterns as latent variables. In addition, the characteristics of each topic were clarified by generating the word distribution.

## SYSTEM FACTORIAL TECHNOLOGY PROVIDES NEW INSIGHTS ON THE DECISIONAL MECHANISMS UNDERLYING SELECTIVE ATTENTION PROCESSES IN ELITE VOLLEYBALL PLAYERS

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### Introduction

Previous research has demonstrated superior selective attention (e.g., global-local processing) in elite volleyball players as compared to non-athletes. However, the use of mean measures in prior research may limit the inferences about the decision mechanism underlying perceptual-cognitive expertise in volleyball players. To address this issue, we employed a non-parametric and diagnostic tool, Systems Factorial Technology (SFT, Townsend & Nozawa, 1995), to explore the information processing characteristics of elite volleyball players.

### Methods

Male professional volleyball players and a set of health-, gender-, and age-matched non-athletic controls were recruited to take part in the experiment. All the players were competing at the highest level in national events at the time of the study. Data were recorded while participants performing a double factorial version of global-local task which allows the measure of visual selective attention and decision-making. SFT was used to infer three crucial properties in a process model, including processing architecture, stopping rule, and processing capacity.

### Results

The results of mean measures revealed that volleyball players showed higher accuracy but slower responses than the non-athlete controls, suggesting that the two groups may adopt different response strategy to perform the task. On the other hand, the SFT results revealed that volleyball players adopted a serial processing strategy to detect redundant global-local features, whereas the controls adopted a parallel processing strategy. Both groups followed a self-terminating rule for decisions; that is, either global or local features were sufficient for decisions, a decision was made and the other process was terminated. In terms of processing capacity, we found that volleyball players showed unlimited-capacity to supercapacity processing, while the controls exhibited unlimited-capacity processing.

### Discussion

Our results indicate that extensive experience with volleyball training may affect the processing architecture and the processing capacity but not the decisional stopping rule. Although the volleyball players serially processed the global and local features, they might only need partial information of the second stimuli to make decisions. More importantly, their processing efficiency may increase as workload increases, suggesting a greater ability to simultaneously process both global and local visual information relative to the controls. In sum, the current findings provide empirical evidence to indicate that the perceptual comparison and decision processes may be altered through long-term sports training.

## THE POSITIVE RELATIONSHIPS BETWEEN COGNITIVE FUNCTION AND PHYSICAL FITNESS IN NON-ELITE YOUTH SOCCER PLAYERS

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### INTRODUCTION

Soccer players have acquired superior skill and physical fitness due to habitual skill, agility, endurance, and strength trainings. It was also suggested that cognitive performance was also enhanced by these trainings [1], [2]. Previous studies reported that cognitive function was positively related to dribbling, ball control, and ball juggling in elite youth soccer players [3]. However, the relationship among physical

fitness, dribble skill, and cognitive function in non-elite youth soccer players is unclear. Therefore, the aim of this study was to investigate the relationship among cognitive function, physical fitness, and dribble skill in non-elite youth soccer players.

#### METHODS

Twenty-one male non-elite youth soccer players aged 13-14 performed a cognitive test (Stroop Color-Word Test), a physical fitness test (e.g. sprint 20-m, change of direction, and Yo-Yo Intermittent Recovery Test), and a dribble test. The cognitive test was conducted on a different day from other tests within the same week. The Spearman's correlation coefficient test was used to investigate the correlation between cognitive and other test performances.

#### RESULTS

Spearman's correlation tests showed that general cognitive function reflected in the color condition of the Stroop test was negatively associated with sprint performance [ $r_s(19) = -0.459, p = 0.036$ ], and positively associated with endurance performance [ $r_s(19) = 0.439, p = 0.046$ ]. Moreover, inhibitory control reflected in the incongruent color-word condition of the Stroop test was positively associated with endurance performance [ $r_s(19) = 0.453, p = 0.039$ ]. On the other hand, dribble test was not correlated with any of the Stroop test conditions.

#### CONCLUSION

It is necessary for successful performance in soccer players to improve physical fitness and decide rightly execution and inhibition based on visual information involved in spatial location and motion of ball and/or other players. These findings suggest that there were positive relationships between cognitive functions involved in executive control such as inhibitory control and physical fitness (sprint and endurance performances) in non-elite youth soccer players.

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### **ANALYSIS OF A MENTAL SUPPORT PROGRAM THAT USES A PSYCHOLOGICAL COMPETITIVE ABILITY TEST RECALLING THE PAST - WITH FOCUS ON THE TOTAL SCORE PRIOR TO THE MENTAL TRAINING PROGRAM -**

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#### Introduction :

It has been reported that psychological factors are important for improving athletes' performance. We took particular note of psychological competitive ability in this respect and previously developed psychological competitive ability test recalling the past (recalling test) for college athletes. Further, we demonstrated that the recalling test might have high validity to assess past psychological competitive ability and that our mental support program which combines the mental training with the recalling test was useful because the effects of the mental training program were comparable to not only pre-training but also past psychological competitive ability in college athletes. In this study, we examined the effects of our mental support program that uses the recalling test with focus on the total score prior to the program.

#### Methods :

To examine the effects of our mental support program that uses the recalling test, 16 college athletes participated in the mental training program to enhance their mental performance for approximately two months after completing the recalling test. They only took the real test after the training program, and the effects of the training program on psychological competitive ability were subsequently analyzed. They were divided into two groups, respectively (HG, n=8; high-scoring group, and LG, n=8; low-scoring group), on the basis of their total scores on the test prior to their training program, and the effects of the training program on the HG and the LG were analyzed.

#### Results :

Their total score on psychological competitive ability test in the HG was increased from  $193 \pm 16$  (mean  $\pm$  SD) before mental training program to  $203 \pm 16$  after the program. On the other hand, their total score on the test in the LG was increased from  $144 \pm 23$  before mental training program to  $182 \pm 21$  after the program. The improvement rate of their total score on the test after their training program was  $5 \pm 11\%$  in the HG and  $29 \pm 21\%$  in the LG, significantly higher for the LG than the HG ( $p < 0.05$ ).

#### Discussion & Conclusion :

The results in the HG and LG confirm that the mental training program is especially useful for college athletes with a low total score on the test prior to their program. Our mental support program which combines the mental training with the recalling test is capable of effectively enhancing their mental performance by paying attention to pre-training and past psychological competitive ability in college athletes.

### **PSYCHOLOGICAL TRAINING IN PREPARATION FOR THE 10TH ACROBATIC GYMNASTIC EUROPEAN (2019)**

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#### Introduction

High level competition in gymnastics requires long training processes. Gymnasts need to demonstrate the results of their training in short moments during the competition. This leads to high demands on their mental strength and plays an important element in their success. This brief aims to illustrate the influence this mental training played in the Acrobatic Gymnastic European competition 2019.

#### Method

We studied a 15 year old female participant (n=1) member of the Spanish National team in her training towards this competition. The program was requested by her trainers and was approved by her parents. It lasted 5 weeks in which the psychologist worked in situ in 3 out of the 5 weekly sessions (a total of 15) and ended 4 days before the competition started. To monitor the influence of this training, the gymnast answered the questionnaire "Psychological Characteristics Related with Sports Performance", before the program started and once it had been completed. This questionnaire measured the following: Stress Control, Motivation, Mental strength, influence in the performance and cohesion; the result offered a coefficient of internal consistency (Cronbach alfa 0.85). The training program followed the following pattern:

The first week set the base strengths and weaknesses; we observed the gymnast during training, interviewed her trainers, parents, the gymnast herself and finally carried out the questionnaire.

Once the collected information was analysed we established and scheduled a training program with three primary objectives: (1) increase self-confidence in weeks 2, 3, 4 and 5; (2) improve group cohesion in weeks 1 and 2; and (3) improve stress control during weeks 3, 4 and 5. To achieve the set objectives, the psychologist worked directly with the gymnast communicating the objectives, offering techniques to control and register activation and control of inner dialogue. The psychologist agreed with the trainers changes to her program that impacted on the technical and physical elements of her training, particularly a decrease in the volume and number of competition run throughs.

#### Results

We analysed the results of the questionnaire before and after each training through the non parametric test Wilcoxon, which yielded significant results ( $p < .05$ ), 028.

#### Discussion

These findings could suggest that the training undertaken influenced the psychological abilities that we focused on and could have contributed towards the excellent results that the gymnast displayed at the competition.

## THE CURRENT STATUS OF SMARTPHONE ADDICTION BY UNIVERSITY ATHLETES AND PREVENTION EDUCATION

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#### Introduction

Recent increase in use of smartphones causes rapid increase of smartphone addiction. According to a survey on smartphone dependence by the Korea Institute of Information Technology Promotion (2019), the risk group of smartphone dependence is increasing every year. In particular, the group of their 10s and 20s shows a high level of addiction. This study aims to examine the effects of the smartphone use on exercise and schoolwork of university athletes through a survey on the smartphone addiction level, and discuss the need of prevention education.

#### Methods

This study surveyed 52 student athletes at the K University located in Seoul to investigate the actual condition and the addiction level of the smartphone use among university athletes. Youth Smartphone Addiction Diagnosis Scale (Korea Information Society Agency, 2011) and the open questionnaire developed by expert meetings are used for the survey tools. The sub-factors of the smartphone addiction diagnosis scale are daily life disorder, withdrawal, and tolerance, and are composed of the Likert 4-point scale. The open questionnaire consists of 10 questions regarding thinking and actual use of smartphones during classes and the awareness of smartphone addiction prevention. The collected data were analyzed by T-test, chi-square test, inductive categorization, and triangulation according to the research purpose.

#### Results and discussion

First, the result of t-testing on university athletes gender difference in the smartphone addiction shows that it is higher among females than males. Among the subfactors, females were significantly higher than males in withdrawal and tolerance. Second, chi-square tests, according to the smartphone addiction level, are performed on the following three questions: Usefulness of the smartphone for exercise and study, experience of class participation without the smartphone, and awareness of the smartphone addiction. The results reveal that the high risk and potential risk groups showed significantly higher distributions than the general user group. Third, the result of an open questionnaire survey shows that university athletes are highly dependent on smartphones, seek pleasure and acquire information by using smartphones. For the addiction prevention, the general user group and potential risk group required prevention education such as smartphone usage restrictions, risk emphasis, self-regulation methods, damage cases, and usage time adjustment. On the other hand, the high-risk group answered either no idea or to leave it under their own control.

#### Discussion and conclusion

The result of the survey shows that university athletes are highly dependent on the smartphone, their awareness of addiction and requests of prevention education differ by the level of the addiction.

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## PSYCHOLOGICAL EVALUATIONS PERFORMED TO FOOTBALL ACADEMIES

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#### INTRODUCTION:

The use of science and technology applied to sports demands the investigation of effective methods and techniques that allow the increasingly necessary improvement of sports training and the inclusion and participation of the psychologist as a permanent demand and tool in team sports. Today the tactical preparation, its control and evaluation form in the sports training process is recognized as the first step to develop and improve in teams of 1st category in Mexico and the world, as well as the psychological preparation, imbued within the tactical preparation, that is why the great sports potencies in the world are currently striving to optimize this important process of preparing the athlete. Sports psychology has developed and consolidated its presence in the entire field of competitive sports practice. This science acts in the individual and group aspect, teaching the athlete to eliminate negative thoughts or to use concentration techniques, in addition to making the smartest decision at the most suitable moment. Sports Psychology nourishes from the sources of Social Psychology for the necessary explanation of these phenomena considering the background and development of social thinking (Predvechni and Sherkovin, 1986).

#### METHOD:

The evaluation consisted in the application of a battery of psychological variables tests, which were applied in January and April 2019 to four categories of the Football Club. 11 psychological constructs were evaluated in total, its descriptive statistics were calculated according to category (U20 - U17 - U15 - II) and the moment of application (T1 and T2). Likewise, the changes in the psychological variables were analyzed according to the moment of application, the prediction of burnout and satisfaction with the life of T2 was analyzed based on the interpersonal styles of the coach generated in T1.

#### RESULTS AND DISCUSSION:

According to the results of the study both in the comparisons by variables, times (T1 and T2) and categories, it is important to act in a brief form in the sub-20 and second division categories, since they are at risk of truncating an adequate integral development of the soccer player, predicting a burnout and few intentions to continue with a physically active life as soon as he concludes his stage as professional soccer player.

**FINANCE:**

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**PSYCHOLOGICAL FACTORS ASSOCIATED TO PREVENTION AND REHABILITATION OF SPORTS INJURIES**

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**INTRODUCTION:**

Some of the main psychological models from Andersen & Williams (1988), and Olmedilla & García-Mas (2009), offers a general panoram about psychological factors and the incidence of sports injuries. In which the stress is a variable that can affects some athletes in the appearance of an injury. It can even affect the rehabilitation and recovery process (Olmedilla; Rubio; Ortega. & García-Mas, 2016).

**AIMS:**

To know which are the main psychological factors associated to sports injuries.

Define the main prevention and intervention methods around an sport injury.

**METHOD:**

A literary review was carried out in the databases (Redalyc, PubMed, Scielo, ScienceDirect y PsychInfo) of 17 articles related to the incidence of sports injuries, of which 3 of them were proposed theoretical models, 7 of them were systematic reviews of the main interventions in sport psychology applied to sports injuries and 7 were interventions for prevention or recovery of the injury.

**RESULTS:**

According to Olmedilla and García-Mas (2009), both physiological and psychological stress can cause athletes to be prone to having a sports injury at some point during their sports season. In addition to the sports injury can also affect the emotional state in which the athlete is, thus altering his anxiety state and the degree of stress that is perceived. So it can interfere with the recovery process of the athlete.

It has been found that psychological interventions aimed at reducing stress are favorable for the recovery process and decrease the risk of injury. Among the main intervention techniques are: diaphragmatic breathing relaxation, Jacobsons progressive muscle relaxation, imagery, psychological biofeedback and Mindfulness (Ortín; Olivares; Abenza; González. & Jara, 2014).

**CONCLUSIONS:**

It is concluded that stress is an important factor that influences the incidence and prevalence of sports injuries. In addition, the psychological intervention strategies aimed to reduce the stress level, can favor the prevention and recovery process of sports injuries.

**FINANCE:**

Financial investigation for the Project UANL-PTC 511-6/18-8928

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**AEROBIC PHYSICAL EXERCISE AS A COMPLEMENTARY INTERVENTION FOR COGNITIVE REHABILITATION IN SURVIVORS OF SEVERE TRAUMATIC BRAIN INJURY**

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**INTRODUCTION**

There is evidence from animal research that physical exercise (PE) can contribute to cognitive recovery after traumatic brain injury (TBI) by means of neuroprotective and neurorepair mechanisms. However, the number of studies on the possible benefits of PE on cognition in patients with moderate and severe TBI is scarce. Our aim was to examine the effects of an aerobic PE intervention, administered in addition to usual cognitive rehabilitation, on several cognitive domains and on heart rate variability (HRV) in survivors of severe TBI suffering from chronic cognitive impairment.

**METHODS**

Six severe TBI patients at the chronic stage (2 of them with hemiparesis) that were receiving neurological rehabilitation in outpatient centers (AVAN Neurologia or INA Memory Center) participated in the study. A comprehensive neuropsychological assessment (working memory, executive function, attention, language, long-term memory, visuospatial function) and a quality of life scale were administered before and after the intervention. Heart rate variability (HRV) at rest was recorded repeatedly, and actigraphy recordings of physical activity (PA) in daily life were taken prior to and during the PE period. The intervention consisted in 3 30-min weekly sessions of supervised aerobic PE for 17-20 consecutive weeks. Hemiparetic patients exercised in a rehabilitation leg ergometer while sitting on a chair. The patients without motor impairment alternated the use of a leg ergometer with the use of a static bicycle and a treadmill. A 60-80% of heart rate reserve (HRR) was established as exercise target intensity, and HRR and ratings of perceived exertion (RPE) were monitored every 5 min.

**RESULTS**

Compared to pre-PE assessment, a significant improvement was found in trail making test-B (alternating attention) and tower of Hanoi/test of the rings (planning abilities). Post-intervention performance in several cognitive tests correlated positively with moderate-to-vigorous PA (that increased during the intervention), or negatively with sedentary time (that was reduced during the intervention). No significant changes were found in HRV and quality of life scores, but the latter showed positive correlations with amount of HRV. In contrast to the participants without hemiparesis, patients with hemiparesis failed to reach the target intensity in most sessions. There was very poor correspondence between RPE and HRR.

#### CONCLUSIONS

Supervised aerobic PE interventions may contribute to reduce some cognitive deficits in severe TBI patients even when initiated at the chronic stage. PA in daily life also seems to contribute to the cognitive benefits. The reasons why RPE and HRR show poor correspondence in patients with severe TBI (as in subacute patients\*) require further investigation.

\* Morris, T.P, et al. (2018). Feasibility of aerobic exercise in the subacute phase of recovery from traumatic brain injury: A case series. *Journal of Neurologic Physical Therapy*, 42: 268-275.

### EFFECTS OF WALKING INTENSITY ON COGNITIVE FUNCTION IN OLDER ADULTS WITH MILD COGNITIVE IMPAIRMENT (MCI): A PILOT RANDOMIZED CONTROLLED TRIAL.

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#### INTRODUCTION:

Exercise is known to promote physical and mental health. The physical activity recommendations put forth by the World Health Organization can improve cardiorespiratory, metabolic, musculoskeletal, and functional health, prevent breast and colon cancer, as well as alleviating depression. However, the effects of these recommendations on cognitive health in older adults remain unknown. In 2018, the American Academy of Neurology reported that the relative risk for developing dementia in older adults with mild cognitive impairment (MCI) is 3.3 compared to cognitively normal older persons. As exercise provides a multitude of benefits for healthy aging, its efficacy in improving cognition in the MCI population therefore warrants investigation to supplement current physical activity guidelines.

#### METHODS:

The present study was a 12-week single-blind randomized controlled trial (RCT). Fifteen older adults (aged  $\geq 50$  years) with MCI (diagnosed by Montreal Cognitive Assessment – Hong Kong version (MoCA), using the 7th percentile of the age- and education-adjusted cutoff) were randomized to control (CON), once-a-week moderate-intensity walking (MOD), or once-a-week vigorous-intensity brisk walking (VIG). Subjects in the CON group (n = 5) performed light-intensity stretching, whereas subjects in the MOD group (n = 5) and the VIG group (n = 5) performed walking exercise on a motor-driven treadmill for 150 minutes at 3.5 METs and 75 minutes at 7 METs once a week respectively.

#### RESULTS:

After 12 weeks of intervention, the subjective cognitive ratings did not differ between the groups ( $p = 0.38$ ). However, MoCA scores of both walking groups improved significantly compared to CON. MoCA of CON, MOD, and VIG improved by 1.1%, 30.9%, and 31.5% respectively ( $p < 0.001$ ). MOD and VIG also performed better than CON in the Stroop colour test. The time required dropped by 8.3% in VIG, and increased by 0.6% in MOD and 54.5% in CON respectively ( $p < 0.001$ ). VIG performed better than CON in verbal fluency in animals. The total number of responses increased by 21.8% in VIG, and dropped by 5.5% in CON ( $p = 0.003$ ). VIG performed better than CON in forward digit span. The total number of correct responses increased by 3.6% in VIG, and dropped by 12.2% in CON ( $p = 0.034$ ).

#### CONCLUSION:

Twelve weeks of walking training led to significant improvement in MoCA scores compared to control conditions, which also prevented the decline in cognitive functions in older adults with MCI. Despite no significant differences in any neurocognitive tests between the walking groups, vigorous-intensity brisk walking might be more beneficial as it prevented the decline in multiple cognitive domains, including executive function and working memory, while moderate-intensity walking only prevented the decline in Stroop colour test performance compared to control conditions. RCTs with larger sample sizes are warranted to validate the effects of walking intensity on improving cognitive functions in older adults with MCI.

### EFFECTS OF WALKING INTENSITY AND FREQUENCY ON IMPROVING MOOD IN OLDER ADULTS WITH DEPRESSIVE SYMPTOMS: A PILOT STUDY

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#### INTRODUCTION:

The World Health Organization recommends to perform 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic-type physical activity weekly for reducing the risk of depression. However, limited longitudinal studies have examined the effects of exercise intensity and frequency of physical activity on alleviating depression.

The purpose of this study was to compare the effects of walking exercise under different exercise frequencies (i.e., regular exercise pattern vs. weekend warrior) and intensities (i.e., moderate-intensity vs. vigorous-intensity) on alleviating depressive mood in older adults with depressive symptoms.

#### METHODS:

Thirty-one older adults (age $\geq 50$  yrs) with depressive symptoms (scored 8 or higher out of 21 in the depression subscale of Hospital Anxiety and Depression Scale) were randomly assigned to: 1) attention control group (CON, performed one weekly session of 75 minutes of static stretching exercise for 12 weeks, n=7), 2) moderate-intensity regular walking exercise group (MOD $\times 3$ /wk, attended three 50-min training sections weekly for 12 weeks, n=6), 3) moderate-intensity weekend warrior walking exercise group (MOD $\times 1$ /wk, attended a 150-min training sections weekly for 12 weeks, n=6), 4) vigorous-intensity regular walking exercise group (VIG $\times 3$ /wk, attended three 25-min training sections weekly for 12 weeks, n=6), and 5) vigorous-intensity weekend warrior walking exercise group (VIG $\times 1$ /wk, attended a 75-min training sections weekly for 12 weeks, n=6). Participants in MOD $\times 3$ /wk and MOD $\times 1$ /wk walked on the motor-driven treadmill at heart rate equivalent to 3.25 metabolic equivalent of tasks (METs) during training, whereas participants in VIG $\times 3$ /wk and VIG $\times 1$ /wk brisk walked at heart rate equivalent to 6.5 METs. Depressive symptoms and anxiety symptoms were measured by Hospital Anxiety and Depression Scale before and after the 12 weeks intervention.

**RESULTS:**

Depression level was significantly reduced after 12 weeks of regular walking exercise (CON -17.7% vs MOD×3/wk -54.1% and VIG×3/wk -67.2%,  $p<0.01$ ). In weekend warrior exercise groups, only vigorous exercise reduced depression level (CON vs VIG×1/wk -39.1%,  $p<0.05$ ). Both regular walking exercise group showed reduced anxiety level (CON -3.4% vs MOD×3/wk -44.0% and VIG×3/wk -65.6%,  $p<0.01$ ), but the decreases were not observed in the weekend warrior exercise groups.

**CONCLUSION:**

Our results demonstrated that regular walking exercise with either moderate-intensity or vigorous-intensity reduced depressive level and anxiety level among older adults with depressive symptoms. Our findings suggested that weekend warrior exercise pattern (less frequent bouts of exercise weekly) with vigorous intensity is a practical approach to improve mood.

### **THE FIRST PERFORMER'S DISADVANTAGE IN GYMNASTICS COMPETITION DISAPPEAR BY PRESENTING JUDGES THE REFERENCE PERFORMANCE AND THE SCORE**

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**Introduction**

In competitions of aesthetic sports such as gymnastics, where the judges evaluate scores subjectively, there is an order bias where the order of the performances affects the scores. Because the very first performance of a sequence serve as a standard of comparison (1), in particular, the scores of the first performer tend to be low (2). The disadvantage of the first performer is very problematic from a fairness perspective in competition. Here, we propose a method of presenting judges with a reference performance before starting scoring to standardize the criteria for judges. Thus, the purpose of this study is to verify whether our method can change the score of the first performance and diminishes the disadvantage of first performer.

**Methods**

Eleven subjects with a certified judge license participated in this study. All subjects performed three sessions. In the basic session (BS), subjects watched and scored five sets of six consecutive performances. These thirty performances were chosen from the movie of the 2016 pre-Olympic game. In the order changing session (OCS), subjects performed scoring of the same thirty performances, but the performance order of the first and the sixth player in the BS were replaced each other in each set. In the standardized criteria session (SCS), subjects performed the same session as the BS, but viewed the common performance and its score before starting the first set. We adopted the performance with the closest score to the average score of all performances in the 2019 World gymnastics competition as the common performance. The order of the sessions was counterbalanced by the subjects. Using a one-way ANOVA, we analyzed only the scores of the same performance of the first set in each session, that is, the first performance in the BS and the SCS, the sixth in the OCS.

**Results**

There was a main effect in scores between sessions ( $F=14.015$ ,  $p<0.001$ ). As a post-hoc test showed that there were significant differences ( $p<0.001$ ) in the score between the BS ( $7.84\pm 0.21$ ) and the OCS ( $8.34\pm 0.27$ ) and between the BS and the SCS ( $8.29\pm 0.18$ ), but not between the OCS and the SCS ( $p=0.901$ ).

**Discussion**

First, we confirmed the disadvantage of the first performer because the score of the BS was significantly lower than that of the OCS. Next, we found the score of the SCS was higher than the BS and as same as the OCS. This result suggests that the disadvantage of the first performer disappeared when the reference performance and its score was presented before starting scoring. Therefore we conclude that our proposed method is effective in dealing with the order bias, especially in the disadvantage of the first performer, in competitions of aesthetic sports.

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### **FROM PLAY AND INTENDING TO REST – TO SEVERAL WORLD CHAMPIONSHIPS AND BEING THE BEST! - PROCUREMENTS OF EXPERT PERFORMANCE IN BIATHLON**

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UNIVERSITY OF AGDER

**Introduction**

Many intermediate endurance athletes exercise as much as the best athletes in the world (Tønnessen et al., 2014), so what determines which athlete achieve the best results? Elite performers are shown to have engaged in deliberate-practice activities such as specific goals to improve performance, successive refinement through repetition, feedback and instruction specifically designed to improve their performance from an early age (Ericsson, 2014). The purpose of the present study was to analyse different psychological characteristics of a biathlete at a high international level, and to investigate the factors related to the early life (Côté, 1999) and relationships that contributes to the athletes performance development.

**Methods**

The study was conducted as a single case study, and one respondent was recruited based on defined inclusion criteria. Data were mainly collected through personal depth interviews with semi-structured interview guides. The recordings from the interviews were transcribed, data was structured, and categories emerged. Data was also collected utilizing questionnaires and observation to supplement data from the interviews.

**Results**

The findings show that the respondent has several psychological characteristics that all contribute to achievement at a high international level. The characteristics that portray the respondent are mental toughness, adaptive perfectionism, sport-specific intelligence, high levels of high confidence, as well as appropriate sources of motivation. The respondents early life and significant others like balanced and supportive parents, teammates, and dedicated coaches throughout the career are also seen as factors that have contributed to the performance development of this athlete.

**Discussion**

This study is a minor contribution to the field of performance development within sports psychology. Although the content of practice tasks will necessarily differ from domain to domain, the findings seem to be transferable to the elite athlete context of other individual



sports. However, more research is warranted to investigate performance development in an elite sport context with a comprehensive perspective.

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## SOCIOLOGY

### SOCIOCULTURAL CONSTRAINTS IN ELITE SPORT: WHAT PLACE DOES SPORT HAVE FOR WOMEN?

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#### BACKGROUND

Female sport has experienced a significant growth over recent years with raising numbers in sponsorship opportunities or investments made to grassroots academies. This has generated more public interest and started the process of normalising females' participation in sport. Increased attention and popularity of female sport put into public eye issues associated with other-than-white heterosexual male players in relation to prize money or player salaries. Indeed, highlighting player characteristics such as female World Cup emphasises segregation and assumes the default option being male (Coakley, 2009). Empirical literature in motor development and skill acquisition offers thorough theory to suggest that sociocultural factors (e.g., gender stereotypes) and patriarchy restrict athletes' development needed to achieve full potential. We argue that while sociocultural constraints have been well established in theory, little empirical research has looked at gender-based stereotypes as a sociocultural constraint in elite sport. This would imply that research adopts stereotypes rather than theory.

#### METHODS

A scoping review was conducted investigating the use and applications of Newell's Model of Constraints (1986) to expertise acquisition in sport. PRISMA guidelines were followed and four key databases were searched. The main criteria included explicit applications of Newell's model and expert performers-participants.

#### RESULTS

7,999 studies were identified which are currently being screened against inclusion criteria. The final studies will be thematically analysed using Newell's Model before proceeding with analytical induction. Combined, these approaches will help us to develop a better understanding of existing literature, make further comparisons and continually develop our argument. Preliminary results indicate a wide spread of studies that draw on Newell's model but with little explicit application to acquisition of expertise, and a focus on individual constraints while sociocultural constraints focus around coaching pedagogies.

#### DISCUSSION

Results will be discussed in light of existing gap between empirical theory (e.g., Newell's model) and current research and practices (i.e., considering gender as a sociocultural constraint when promoting expertise acquisition). We argue for the need to build on critical sport theory to gain further insights into how sociocultural constraints—gender-based stereotypes—produce and reinforce gender inequities in sport. Strategies and future research implementing empirical evidence in sport sociology to advance current knowledge and practice in sport psychology could be more effective in influencing positive change to achieve gender equality in sport.

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### VICTIM OR WARRIOR: THE REPRESENTATION OF WOMEN ON THE COVERS OF WOMENS SELF-DEFENSE LITERATURE

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#### Introduction

From the practical nature of martial arts and, sometimes, from the combat sports aspect, its use for self-defense in situations of physical risk to an aggression is stripped. Specifically, one of the contexts in which this situation becomes more prominent is in the area of female self-defense. The present work consists of an analysis on the particularities of the covers of informative materials published on female self-defense.

#### Methods

To carry out this work, a methodological design based on the constructivist paradigm was chosen, using the research strategy of the multiple case study. The sample, selected through the technique of documentary review, consists of the covers of 81 works, registered on the Amazon.com platform, with titles in both English and Spanish, which deal with female self-defence. The content analysis technique was applied to this sample, with the help of Atlas.ti software in its 7.5 version. During the analysis procedure, the category system was reviewed twice by external experts and two trainings were carried out by the researchers, until an absolute agreement of .992 was reached.

#### Results and conclusions

According to the authorship of the works, 46 of the total of 81 covers were written exclusively by men and 21 by women. There is a difference of 5.7% in the appearance of the figure of the woman on the covers with respect to the gender of the authors, rising to 27.6% when it comes to the appearance of the man. With regard to age, both groups of authors represent mostly adult women (78.3% with male authorship and 81% with female authorship). The clothing of women that most appears on the covers of works made by men is informal (34.8%), while in works made by women the most common clothing is martial (33.3%). The most common situation in which women appear on these covers is that of assaulted women defending themselves (34.8% of covers written by men and 42.9% by women). Along the same

lines, it can be seen that in works produced by women, no woman appears to be defenceless against an aggression, while in works produced by men, 6.5% of the women appearing are in this situation.

In conclusion, it can be seen that women are represented as adults, wearing informal clothing and defending themselves against aggression, with differences in terms of authorship: female authors never represent defenceless women. This implies that the message transmitted by works written by women is oriented to the consolidation of their autonomy in the defense of their integrity, while that of male authors is in pursuit of their defenselessness in these situations.

## SPORT MANAGEMENT AND LAW

### ATHLETIC MIGRATION IN DUAL CAREER (AMID): CHARACTERISTICS THAT HELP TO IDENTIFY THE STUDENT-ATHLETES' CHALLENGES AND REQUIRED SERVICES

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UNIVERSITY OF SALZBURG

Dual Careers (DC; sports and education) and mobility are priorities in the funding policies of the European Commission. Despite facilitated mobility within the EU and the potentially positive impact of international experience on both careers, DC migrations are associated with challenges and increased numbers of drop-outs. Existing support services are often insufficient and unspecific. The objective of this study was to assess characteristics of DC migrations and the relationship with obstacles, services and effectiveness for specific groups.

A 50-items questionnaire was administered to 245 student-athletes in Europe. Subjects who experienced DC migration (n=140) were considered for further analyses of ordinal (5pt-Likert scale) and metric data on various aspects of the DC status, migration characteristics, received services and outcomes. Kruskal-Wallis- and Spearman-tests were conducted at a significance level of  $p < .05$ .

The only effect of gender emerged in a higher ratio receiving financial support in males (65%) compared to females (46%) ( $p < .05$ ,  $\chi^2 = 4.63$ ). Differences were found between bachelor (B), master (M) and PhD (P) students in organization (B: 51%, M: 42%, P: 0%;  $p < .01$ ,  $\chi^2 = 8.96$ ) and online support (B: 55%, M: 39%, P: 0%;  $p < .01$ ,  $\chi^2 = 10.10$ ) from universities and online support from sports (B: 36%, M: 24%, P: 0%;  $p < .05$ ,  $\chi^2 = 6.07$ ). Tutoring was more often reported in individual (52%) compared to team (33%) sports ( $p < .05$ ,  $\chi^2 = 4.14$ ) and in environmental (E: 66%) compared to non-environmental (NE: 39%) sports ( $p < .01$ ,  $\chi^2 = 6.88$ ). E (38%) received less frequently financial support than NE (60%) ( $p < .05$ ,  $\chi^2 = 5.30$ ). Age correlated with received tutoring ( $p < .01$ ,  $r = .28$ ) and training hours with received tutoring ( $p < .001$ ,  $r = -.41$ ) and decreased sports performance ( $p < .05$ ,  $r = -.21$ ). For the helpfulness of support services (financial, tutoring, organization, online), no differences in gender, study level and sports type and no correlations with age and training hours were found. Helpfulness of support services scored  $3.9 \pm 0.9$  points.

The high ratio of student-athletes migrating for their DC underlines the relevance of the topic. Higher financial support in males may be due to more professionalized and monetized sports environment in some disciplines. Besides, gender seems to be no decisive characteristic in DC migration. Increased support from universities for lower study levels can be reasoned by requirements in attendance, which is a primary obstacle in DC and should be accounted for during planning stages. Team and non-environmental sports show deficits in tutoring and benefit from financial support. This, in addition to the comparable effectiveness of support services, suggests to not generally prioritize particular services. Instead, selection should be based on the specific deficits of a target group. The current findings highlight essential characteristics of DC migration and allow for identifying special needs via general characteristics.

### TYPE OF SERVICES OFFERED FOR GOLF COURSE MANAGEMENT: ANDALUSÍA (SPAIN).

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#### Introduction

Andalusia has become the most important destination for golf tourism in Spain, with 93 golf courses, 26.65% of the total of country. The offer of services is one of the most decisive problems for improving in any of these entities (1) since golf courses generate revenue from two sources: memberships and green fees; particularly in Europe (2). It is important knowing the opinion of the manager about his work in the golf course, to see which parts it considers most important in its work and the operation of the golf course. The main objective is to analyze on the operation and the services offered of golf clubs in Andalusia.

#### Methods

It is a descriptive, non-experimental and transversal study. An ad hoc survey was created about services offered for manager to complete. There were 22 participants. The questionnaire has 9 questions; 7 about the services and 2 for the manager, relative to opinion about this service. This questionnaire has been validated with groups of experts and professionals in physical education, sports management and golf.

#### Results

There were 22 golf courses, 11 less than 250 membership, 95,45% with special price for membership and 66,67% with 18 holes. The most important services for users are: parking, private lessons, electrical trolley and kindergarten, thee services help that people play more times in the golf course and a higher satisfaction and in the other sense the users do not like the control access. The questionnaire is used to know the services of golf course

#### Discussion

This study on the characteristics of golf course managers highlights the following conclusions:

1. Creation of a short and simple tool to detect services best evaluated or users for improvement in golf course from users point of view. The services most evaluated are them that help to the user play golf more comfortable and they value the human relations between user and golf course staff.
2. Regarding their opinion about their job, managers have a very positive assessment, with a third of them very satisfied. As a result, an average value of managers experience of 8.21 out of 10 is obtained. A greater satisfaction of the manager generates greater satisfaction of the users.
3. To know the services provided by the golf course with the ad hoc questionnaire. This tool can be useful to make a diagnosis on the operation of golf course about the services offered in concern to the manager's opinion.

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## DATA-DRIVEN TECHNOLOGIES IN THE SPORTS INDUSTRY: A CONCEPTUAL FRAMEWORK FOR DEVELOPMENT AND INTEGRATION

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### Introduction:

Advances in digital technology have revolutionized the sports industry over the past two decades. From athletic performance, team strategy to fan engagement, marketing, and organizational performance, all have been radically influenced by the technology. In the recent decade, more data-driven technologies have emerged. Technologies such as data mining, machine learning, and artificial intelligence have continued to make a paradigm shift in the way the sports industry operates. The realization of these technologies depends on successful development as well as organizational integration. Successful development relies on the availability of large datasets, advanced computer algorithms, and experts with technical and domain knowledge. Meanwhile, successful integration depends on a fundamental understanding of the industry, deployment infrastructure, and, ultimately, workforce and management training. There have been many successful academic examples of data-driven technologies for sport; however, full end-to-end development and integration of these technologies remain a challenge. In this work, we propose a unified development and integration framework for stakeholders in the sports industry ecosystem.

### Methods:

We performed a systematic search of general frameworks in the sports industry, as well as development and integration frameworks for data-driven technologies. We identified 15 sport industry frameworks and 12 technological development and integration frameworks. Furthermore, we performed an integrative analysis, developing a sports industry framework that embodies distinct entities and their relations, adaptable for the development and integration of data-driven technologies.

### Results:

A sports industry framework was developed with nine stakeholders: athletes/teams, leagues/clubs, stadiums/arenas, fans, brands, media, government, academic/research institutions, and tech companies. Furthermore, a strategical plan for the development and integration of data-driven technologies is proposed. The strategic plan comprises of four phases: talent identification and selection, pre-game preparation, in-game activity, and post-game analysis.

### Conclusion:

We anticipate that data-driven technologies will deliver enormous promises for the sports industry from the reduction of frictions and the rise of efficiencies. However, full end-to-end development and integration of data-driven technologies in the sports industry remain a challenge. The proposed framework enables the sport industry managers to plan a strategy for their organization. Using this framework, sport industry managers can bring technological benefits to their organizations.

## SPORT TECHNOLOGY

### VALIDITY AND RELIABILITY OF WEARABLE RESPIRATORY GAS ANALYZERS

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### INTRODUCTION:

The objective of this study was to evaluate the validity and reliability of measurements of a wearable respiratory gas analyzer compared with those from a lab-cart respiratory gas analyzer.

### METHODS:

The participants were nine male physical education college students. Comparisons of a wearable respiratory gas analyzer, VO2 Master (Health Sensors Inc., Canada), and a lab-cart analyzer, Aero Monitor AE-300S (Minato Medical Science Co., Ltd., Japan) were performed. M size (30–160 l/min) venturi tubes were used to control the ventilatory volume for the VO2 Master. Measurements included pulmonary ventilation (VE) and oxygen uptake (VO2). The experiment was a submaximal running test using a treadmill. The running speed was set at an inclination angle of 0% within a range of 160 m/min to 320 m/min depending on the running ability of the participants; five speeds were tested in repetitions of 3-min runs with 1-min rest intervals.

Data are presented as the 1-min means of the data for a running period of 2-3 min. Forty-five data points were collected for VE and VO2 from nine participants at five running speeds. The validity and reliability analysis of VE and VO2 were performed as a comparison of intra-class correlation coefficients (ICCs) using Case 2 (2,1) and Bland–Altman methods.

### RESULTS:

The ICCs for VO2 Master and AE-300S were 0.926 for VE and 0.545 for VO2. The mean differences between the VO2 Master and AE-300S analyzers according to the Bland–Altman method were 4.18 l/min for VE and 595.6 ml/min for VO2. The 95% limits of agreement ranged from –12.26 to 20.62 l/min for VE and from 77.0 to 1114.2 ml/min for VO2 excluding zero. The mean VE from 45 data points using the VO2 Master was 76.00 l/min and 35.20 ml/min for VO2. The percent errors for VO2 Master and AE-300S were 21.6% for VE and 27.8% for VO2.

### CONCLUSION:

Oxygen uptake in the VO2 Master was concentrated downward overall, relative to a virtual straight line of  $y = x$  (line on identity) for measurements using the AE-300S; the VO2 Master had lower values than the AE-300S. According to the Bland–Altman method, there were statistically significant proportional errors for VE. On the other hand, VO2 was biased in a positive direction, demonstrating that all measurements in the VO2 Master were lower than those in the AE-300S and that fixed errors existed.

The percent errors in VE and VO2 between VO2 Master and AE-300S were 21.6% and 27.8%, and no interchangeability between the devices was found. Yoza et al. (2013) found that the driver of systematic errors across analyzers differs depending on the sensors used, and Vafa et al. (2017) suggested that a factor leading to low tidal volumes and underestimation of oxygen uptake may be the use of large-sized

venturi tubes. Thus, improvements in the size of venturi tubes and the development of analysis software to compensate for differences in the sensors are required to increase the interchangeability for the VO<sub>2</sub> Master with measurement values from other analyzers.

## **FACTORS' ANALYSIS AND RESULT PREDICTION OF CHINESE SUPER LEAGUE**

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### **INTRODUCTION:**

It is very important for coaches of all football clubs of Chinese Super League(CSL) to analyze the factors that affect the game and evaluate their importance. It helps coaches to improve the effectiveness of training, and to organize the game with arranging better defense tactics. Based on the data provided by Champion®, this paper also tries to predict the result of the game. To a certain degree, this prediction leads to a more reasonable tactics for a team, for an experiencing coach.

### **METHODS:**

For all the data of the winning and losing matches in the home and away field, 64 variables are selected: pass, set piece, attack, confrontation, defense, fault and foul, goalkeeper specific, organization and so on. Here, we exclude the variables directly related to the winning and losing of the match, such as the number of shots, assists, key passing, shooting right, shooting deviation and so on. All variables are standardized, and the data set is randomly divided into training set and test set according to the ratio of 7:3. The training set data is fitted with logistic lasso model, and then cross validation method is used to give the validation results.

After the statistical data processing of 1920 team matches of CSL from 2014 to 2017, each machine learning classification model is trained in the training set, and some models are adjusted; in the test set, support-vector machine(SVM) model performs best.

### **RESULTS:**

It has positive influence on the outcome of the game: the success rate of the front pass, the success rate of the midfield pass, the success rate of the long pass, the home and away field and other variables; it has negative influence on the outcome of the game: the success rate of the Oolong pass, the backcourt pass, the number of red cards, the goalkeepers attack, offside season and other variables. The accuracy of SVM to predict the winning and lost of CSL is about 84.5%.

### **CONCLUSION:**

## **DEVELOPMENT OF EXERCISE USING HOOPS IN PHYSICAL EDUCATION**

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### **INTRODUCTION:**

The exercise using hoops is often used in physical education. In rhythmic gymnastics, it exists as an independent division, and various techniques are developed in the competition. In the praxis of physical education, there are few types of hoop exercise. The reason is that research on effective physical education using hoops is underdeveloped.

The purpose of this study was to contribute to the improvement of the teaching method of physical exercise in physical education by developing exercise play using hoops and balls and verifying its effectiveness.

### **METHODS:**

The method proceeded as follows.

- 1) Investigation of teaching materials and teaching examples using hoops in physical exercises.
- 2) Showing the physical ability in common with them, and clarified the elements that were lacking in the conventional teaching materials.
- 3) A new type of exercise was developed.
- 4) The effectiveness of the exercise was verified.

### **RESULTS:**

It can develop the ability to dextrtous movement in the exercise using hoops. The lack of ability on this element was coordination ability. The newly developed exercise material was an exercise that required simultaneous manipulation of the ball and hoop.

### **CONCLUSION:**

The above results revealed the following.

- 1) It has been found that exercise with a new ball and hoop enhances dextrtous movement.
- 2) By combining the ball and the hoop, the coordination ability could be improved.
- 3) It was found that the communication ability was improved by implementing in the group.

Through these considerations, effective knowledge was obtained for physical education teachers on exercise using hoops.

## **ASSESSMENT OF BIOLOGICAL MATURATION IN YOUTH FEMALE SOCCER PLAYERS: AGREEMENT BETWEEN GREULICH-PYLE AND FELS PROTOCOLS**

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1: UNIVERSITY OF COIMBRA, 2: LUSÓFONA UNIVERSITY OF HUMANITIES AND TECHNOLOGIES, 3: UNIVERSITY OF COIMBRA, 4: PORTUGUESE INSTITUTE OF SPORTS AND YOUTH, 5: UNESP, 6: LOUGHBOROUGH UNIVERSITY.

### **INTRODUCTION:**

This study was aimed to examine the concurrent assessment of skeletal age (SA) using Fels and Greulich-Pyle (GP) among female youth soccer players.

### **METHODS:**

The sample was composed of 420 participants aged 10.08-16.73 years. Standardized x-rays of the left hand-wrist were obtained and analyzed by an experience technician. SA was determined adopting the above cited protocols. Differences between SA and chronological age (CA) were used to derive skeletal maturity groups: late, average and early maturing. Descriptive statistics were determined, and Cohen kappa coefficient performed to calculate agreement among classifications.

### **RESULTS:**

Fels SA (15.14 years) was, on average, in advance compared to GP SA (14.58 years). Intra-individual mean differences by age group between methods fluctuated 0.60 to 1.31 years. Larger differences between SAs were noted around 14 years of age. Kappa statistics suggest-

ed moderate agreement at younger ages (under-13: kappa = 0.42; under-14: kappa = 0.32) and trivial association at older groups (under-15: kappa = 0.04; under-16: kappa = 0.04).

#### CONCLUSION:

In summary, GP SA was systematically lower than Fels SA among youth female soccer players. In summary, the SA of an individual player represents the CA at which a specific level of maturity of the hand-wrist bones was attained in the reference sample upon which the protocol was developed and, in the current study, differences between the two methods under analysis were substantial. The discrepancies between protocols may have consequences for the verification of CA and for grouping players by skeletal maturity categories. These are central topics in youth sports.

### SMART SUPPORT TOOL FOR COACHES AND TRAINING TRACKING. MOVEAPP

ROIZ-PAGADOR, J., RUIZ, R., CALVO-LLUCH, A., GONZALEZ-REINA, A.

UNIVERSIDAD PABLO DE OLAVIDE

#### INTRODUCTION:

With this project we intend to raise awareness among employers and workers about the benefits of performing physical activity scheduled and periodically oriented in the work environment, conceiving it as a guide towards an increase in the degree of tolerance to work stress and physical and mental fatigue at work, thus achieving an increase in work performance.

Because the most common injuries in the workplace are those of musculoskeletal type related to repetitive movements of the wrist, shoulders and back, together with various circulation problems, especially in the legs, are the number one cause of absenteeism and incapacity to work. We intend to promote physical activity and participation in exercise programs in those companies that seek an effective performance of their workers. The workers who attend the program once a week in person and do at least one more training a week through the App.

#### METHODS:

A computer application is proposed to help experts in monitoring physical activities. It will recommend exercises for each worker, will allow the assigned instructor to track, and will make a recommendation of exercise schedules based on a profile, defined according to the pathologies detected in the patient and their restrictions on the exercises. The instructor supervises the planning proposed by the App, allowing any modification. In addition, the system is intended to learn and adapt in the future according to feedback received from each patient at the end of each session.

This application manages users allowing to maintain an updated and robust level of security. It is scalable and adaptable to different devices using the latest available technologies, taking into account that there is an administration and management area associated with instructors, as well as administrators, and that it is hosted in a web application; and a mobile application, used by users to record and view their activities and request recommendations. This system takes into account the future possibility of expansion and integration with different pathologies and fields close to lifestyles, such as nutrition and rest.

A SF-36 was applied at the beginning and end of the intervention.

#### RESULTS:

Safe, reliable and attractive method creation to improve workers physical condition, as well as functional capacity and pathologies involved. Besides, a drastic decrease in work leave, and a 90.87% adherence to the program was showed. AppTC Moverse execution prevent workers from physical condition and pathologies worsening, saving an average 500€ per user.

#### CONCLUSION:

The research resulting from the collaboration of a large company: ACERINOX, its medical service and the UPO has resulted in the creation and implementation of an App to complement the program of physical activity in the company. It was created from a multidisciplinary work among Sports and Computer Science students.

## SPORTS MEDICINE AND ORTHOPEDICS

### COMPARISON OF LOWER LIMB MUSCLE STRENGTH WITH AND WITHOUT STRESS FRACTURE IN COLLEGIATE FEMALE LONG-DISTANCE RUNNERS

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#### INTRODUCTION:

A stress fracture is a break in bone tissue caused by repeated minor external mechanical stresses such as long-distance running. Warden SJ et al suggested that muscle is supposed to act as a shock absorber for bone during running [1]. From this fact, one of the risk factors of the stress fracture is considered to be weak muscle strength of the lower limbs. The purpose of this study was to clarify the influence of lower limb muscular strength on stress fracture developing by investigating the onset of the stress fracture prospectively after measurements of knee joint extension/flexion muscle strength for female long-distance runners.

#### METHODS:

Twelve female long distance athletes participated in this study. The extensor and flexor muscle strength of the knee joint of all participants were measured, and the occurrence of a stress fracture was monitored for following 2 years. Stress fractures were diagnosed by orthopedic surgeons using diagnostic imaging (X-ray, MRI, bone scintigraphy). Participants who developed a stress fracture during the 2-year follow-up were selected as the Stress Fracture group (SF group), and the other participants were selected as Control group (CON group). All participants had practiced for two years under the same coach. The extension - flexion torques of the knee joint were measured at 60, 180 and 300°/s under concentric contractions (CC60, CC180, CC300), 60 and 180°/s under eccentric contractions (EC60, EC180) using Biodex system3. The peak torque/body weight ratio (N · m/kg), and eccentric contraction /concentric contraction ratio (EC/CC) were also used for analysis.

#### RESULTS:

Six participants developed stress fractures during the follow-up period (SF group). There were a significant differences in the knee flexor strength at EC60 and EC180 between SF group (EC180: 2.0±0.2 N · m/kg, EC60: 2.2±0.3 N · m/kg) and CON group (EC180: 2.5±0.3 N · m/kg, EC60: 2.6±0.2 N · m/kg) (p<0.05). The EC/CC of the knee extension was significantly higher in the CON group(180°/s: 1.8±0.2,

60°/s: 1.5±0.1) than the SF group (180°/s: 1.3±0.1, 60°/s: 1.1±0.1) ( $p<0.0.5$ ). The EC/CC of the knee flexion at 180°/s was significantly higher in the CON group (2.1±0.2) than the SF group(1.8±0.2) ( $p<0.0.5$ ).

#### CONCLUSION:

The result of this study suggested that the extensor-flexor strength of the knee joint under eccentric contraction is important for preventing the stress fracture in female long-distance runners.

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### **SURVEY ON THE PREVALENCE OF ACHILLES TENDON INJURY IN UNIVERSITY KENDO ATHLETES**

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1: SHINSHU UNIVERSITY, 2: UNIVERSITY OF TSUKUBA

#### INTRODUCTION:

Achilles tendon (AT) rupture is a serious trauma with long time to return to play, and a painful chronic disorder of the AT that causes poor performance. Kendo is a Japanese martial art where the athlete wears heavy armour, without shoes, and repeats quick steps and explosive level crossings in the front-rear direction. Several previous studies have reported that Kendo athletes are prone to AT injury. However, these studies had a small number of subjects and were not sufficient to assess the incidence of AT injury in Kendo athletes. Therefore, in this study, we investigated the prevalence of AT injury in many Kendo athletes.

#### METHODS:

The subjects were 1,000 Kendo athletes from 24 universities. A questionnaire survey was conducted by mail. The questionnaire contained the subject's profile (sex, age, age when Kendo was started, and athletic performance history) and AT injury information. Items of AT injury included AT rupture and problems with the lower limbs from the AT (experience, location, age and month of injury occurrence, whether surgery was performed, and whether reinjury occurred). Subjects with incomplete answers and injuries to the AT from causes other than Kendo were excluded from the analysis. The prevalence of AT rupture and problems from the AT to the lower limbs was classified by sex and examined by the  $\chi^2$  test. The significance level was less than 5% and the significance tendency was less than 10%. Other results are discussed in the descriptive statistics.

#### RESULTS:

The total number of valid responses was 730. The study included 510 males, 218 females, and 2 individuals without a description. The mean age was 19.6±1.3 (male 19.7±1.3 and female 19.3±1.3) years. The prevalence of AT rupture was 2.7% (23 cases). This prevalence was significantly higher in female athletes than in male athletes (5.0% [11 cases] vs 2.4% [12 cases];  $p = 0.06$ ). All injured rupture sites were at the left foot. The age at rupture occurrence was 18.1±1.7 (range 16-20) years, and the month of occurrence indicated no injury from June to September. Surgery was performed in 18 patients (78.3%). The prevalence of problems from the AT to the lower limbs was 10.4% (87 cases). This prevalence was also significantly higher in female athletes than in male (17.0% [37 cases] vs 9.8% [50 cases];  $p < .01$ ). The number of problem sites was 14 (16.1%), 65 (74.7%), and 8 (9.2%) on the right and left, respectively. Other results will be presented on the poster.

#### CONCLUSION:

The prevalence of AT rupture reported in the present study was 2.7%, which is considerably higher than that reported in a previous study, where the prevalence of AT rupture due to sports was 81.6% of incidence of 2.1 per 100,000 person-years (Lemme NJ et al. 2018). Notably, all athletes had injuries on the left foot, which is the main crossing foot in Kendo. Interestingly, the high prevalence of this injury in female athletes and the absence of injuries in the summer differed from the results reported in previous studies (Józsa L et al. 1989).

### **JUST LISTEN TO THE ATHLETES. WHY THE 14 - ELEMENT (AMERICAN HEART ASSOCIATION) CARDIOVASCULAR SCREENING CHECKLIST MATTERED IN THE PRE-PARTICIPATION EVALUATION IN FOOTBALL PLAYERS**

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1 PROF.CC ILIESCU EMERGENCY CARDIOVASCULAR DISEASES INSTITUTE, BUCHAREST 2 NATIONAL INSTITUTE OF SPORTS MEDICINE, BUCHAREST 3 ROMANIAN ACADEMY MEDICAL CENTRE, BUCHAREST 4 ROMANIAN FOOTBALL FEDERATION

#### INTRODUCTION:

Introduction. The comprehensive clinical examination (personal / family history; physical exam) is always the first step toward correct health status evaluation and diagnosis of heart anomalies, some of them, with risk of sudden cardiac death.(1)

The study aim is to evaluate the performance of the 14 - Element Evaluation Cardiovascular checklist (14-E Checklist) (2), a screening method for cardiovascular (CV) diseases detection in football players, along with tests (electrocardiography, ECG; echocardiography, Echo) conducted according to guidelines. (2,3)

#### METHODS:

Method. 2014 - 2019 professional football players received cardiologic evaluation. All athletes had clinical exams according to the 14 - E Checklist (Personal History: 7 elements. Family History: 3 elements. Physical examination: 4 elements ). All athletes had ECG (4) and Echo (5) recordings.

Study Group. 421 professional football players (National / Clubs Teams 2014 - 2019). 212 athletes were examined.

#### RESULTS:

Results: Male, 212 (100%), 17-37 yo. Caucasians 164 (77.4 %), Africans 48 (22.6 %).

H 174 ± 2 cm, W 78 ± 1.5 kg, BSA 1.92 m<sup>2</sup>. Blood Pressure 115 ± 2 mmHg.

14 - E Checklist negative (-) no element; 14-E Checklist (+) ≥ 1 element existing.

Gr I. 14 - E Checklist (-) and normal ECG / Echo : 151cases ( 71.2%).

Gr II. 14 - E Checklist (-) and abnormal ECG/Echo : 8 cases ( 3.77%).

Gr III. 14 - E Checklist (+) and normal ECG / Echo : 12 cases ( 5.66%).

Gr. IV. 14 - E Checklist (+) and positive ECG / Echo: 41cases ( 19.3%).

#### CONCLUSION:

Conclusions. Most athletes (71.2%) with normal clinical examination (14-E Checklist) associated normal ECG and Echos. Athletes with abnormal clinical exams had abnormal ECG / Echo revealing cardiac abnormalities, in 19.3%. In few cases (5.66%), abnormal clinical data were associated with normal test.

The cardiac clinical examination is a reliable test, in the athletes' medical check-up.

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#### **ANALYSIS AND CONTROL OF KEY VARIABLES IN PROFESSIONAL BULLFIGHTERS. A CASE STUDY**

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INTRODUCTION:

Bullfighting is an intense, intermittent and non-systematic physical activity which takes place at varying intensities and over different time periods. Unfortunately, literature on bullfighting and variable performance is very scarce and limited. Objective: The aim of this study was to analyze variables associated with the performance of the bullfighter during the bullfight and tentadero (training for a real situation)

METHODS:

Participants were monitored during both an official bullfight and a tentadero. HR parameters, distance travelled, speeds and accelerations were recorded with GPS Technology and anxiety was assessed with CSAI-2R questionnaire.

RESULTS:

Significant differences were found in the subscale of self-confidence ( $P = 0.037$ ; % of change = 5.36%) between bullfight and tentadero in bullfighter. HR parameters reached by the bullfighter varied depending on the bull. Significant differences were obtained between the first bull and the second bull in HRmax ( $P = 0.010$ ; % of change = -2.69), and TRIMPs ( $P = 0.022$ ; % of change = -5.41). There were no significant differences in the average speed reached during each fight, and the average speed the bullfighter maintained during the bullfight was around 2 km/h.

CONCLUSION:

The results showed that physical preparation may affect pre-competition anxiety levels and that the type of cattle and the type of bull used could have an influence on the bullfighter's performance. Also, the results clearly demonstrate how tentadero cannot be used as a specific tool for the improvement of physical condition in bullfighters and how recording HR, mechanical load and anxiety enables us to customize training loads based on the performance shown during bullfighting.

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#### **RELATIONSHIP AMONG AGE, WEIGHT, ISOMETRIC STRENGTH AFTER A BARIATRIC SURGERY**

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INTRODUCTION:

The aims of this research were: to analyse the relationship among age, weight, isometric strength and body mass index after bariatric surgery; and to know if there were differences among age, sitting time, physical activity intensity, time spent in exercising and walking time.

METHODS:

The sample was made up of 21 patients ( $M_{age} = 36,61$ ;  $SD = 9,91$ ; 6 men and 15 women) bariatric surgeries patients were intervened of: Intra-gastric balloon ( $n=12$ ), endoscopic sleeve gastropasty ( $n=2$ ) and Sleeve Gastrectomy ( $n=7$ ).

RESULTS:

To examine the relationship among age, weight, isometric strength and body mass index a linear regression was performed, the results showed that the linear model was significant ( $F=21.44$ ;  $p<.01$ ;  $R^2=.95$ ). Besides, age did not report significant differences among isometric maximum strength, weight and body mass index. On the other hand, to know if there were differences among age, sitting time, physical activity intensity, time spent in exercising and walking time, a linear regression was conducted.

CONCLUSION:

Although the linear model showed significant differences ( $F=8.59$ ;  $p<.01$ ;  $R^2=.93$ ), the age only reported significant differences between age and physical activity intensity. Furthermore, the older that the patients are, the more physical activity intensity they did. As a conclusion, age could not influence on and intervention of post bariatric surgery in the variables: isometric maximum strength, weight and body mass index. In addition, age may influence on the intensity of physical activity of those patients that are older, it reveals that they might be more aware of the importance of physical activity intensity.

#### **CHANGES IN MUSCLE HARDNESS OF THE LOWER LEG USING JUMPING MOVEMENTS-FROM THE VIEWPOINT OF SPORTS INJURIES**

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INTRODUCTION:

Sports injuries such as lower limb and foot injuries are likely to occur even among beginner players. However, the early detection of thin splints is difficult. Thin splints may occur due to repeated running and jumping on hard, concrete, or tar surfaces. The rebound from the

ground after a jumping motion causes loss of muscle tone, and increases the hardness of the gastrocnemius muscle. In particular, an injured player is more likely to be impacted by a landing motion.

The purpose of this study was to investigate the relationship between sports injuries (in the lower legs and feet) and the changes in muscle hardness before and after jumping.

#### METHODS:

In order to evaluate the reliability of the measurement (intra-examiner error and inter-examiner error), three examiners measured the stiffness of the gastrocnemius muscle in 10 subjects. The muscle hardness was evaluated using a muscle hardness meter (NEUTONE TDMZ-2).

This study included a total of 44 male and female students, (4–10 students in each grade) from 4th grade elementary school to 3rd grade junior high school. The students were specially trained in competitive sports. The subjects performed a figure 8 jump, on one foot for 20 seconds. Muscle hardness was measured before and after the jump. In addition, to confirm suspicions of injuries to the lower legs and feet, a medical examination was also performed by an orthopedic surgeon and a physiotherapist.

#### RESULTS:

As a result of three examiners performing three measurements on each of the ten subjects, the intra-examiner errors ICC (1,3) were calculated as .940, .876, and .876. The average value of three measurements was 0.849.

Following medical examination, 28 (65%) subjects were suspected to have injuries in their lower legs and feet. These number of these injuries were higher than injuries in other areas. A two group t test was also performed to evaluate the muscle hardness before and after the jump. It was observed that the t test value was significantly higher after the jump ( $20.1 \pm 5.2$  before the jump;  $23.1 \pm 6.1$  after the jump,  $t = 6.72$ ,  $p < .01$ ). A two-way ANOVA, based on the presence or absence of lower leg / foot injuries, before and after the jump revealed a significant interaction ( $F = 4.70$ ,  $p < 0.05$ ).

#### CONCLUSION:

The results suggest that athletes suspected of having injuries in their lower legs and feet are likely to be impacted during the landing motion. This may cause muscle tension. In addition, evaluating an increase in the muscle hardness, may enable the early detection and prevention of injuries.

### COMPARABILITY AND REPRODUCIBILITY OF WHOLE-BODY VIBRATION TRIALS. ANALYSIS OF THE QUALITY OF REPORTING.

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#### INTRODUCTION:

Whole-body vibration (WBV) is a training modality which has experienced an increase in popularity for the improvement of bone health. However, the wide array of parameters that can be used in this method, regarding the amplitude, frequency and acceleration of the vibration, as well as the effect of potentially confounding variables has hindered the identification of an optimal vibration protocol for eliciting osteogenesis [1]. In an effort to overcome this difficulty, Rauch et al published in 2010 a 13-item proposal for homogenizing the reporting of WBV studies [2]. The goal of the present study is to analyze the adherence to this guidelines in WBV randomized controlled trials (RCT) focused on bone health.

#### METHODS:

Two reviewers independently scanned the PubMed, Web of Science and SportDiscus electronic databases. RCT analyzing the effects of WBV on bone health in humans were extracted. The search was restricted to studies published in English, after 1st of January 2011, in order to guarantee that the selected guidelines were available at the time of publication of the individual studies. The same two reviewers checked the fulfillment of the different reporting items for all studies finally included in the review. Discrepancies in the califications or the inclusion of individual studies were resolved by consensus between the two reviewers, Arbitration by a third reviewer was used for unresolved disagreements.

#### RESULTS:

The initial search returned 150 results, from which 31 were removed as duplicates and 83 for not fulfilling the inclusion criteria. The mean number of items reported within the 36 included RCT was of 7.25 (SD: 2.02), with only three studies explicitly stating 10 or more of the 13 items and seven that reported 5 or less items.

It can also be observed that there are some parameters that are commonly reported, such as the model of the platform or the vibration frequency (both included 32 in of the 36 RCT) and others that are rarely specified, like the measurements taken to ensure the correct calibration of the platform or the continuous contact between the platform and participant, with only five and one studies mentioning them, respectively.

#### CONCLUSION:

Authors of RCT evaluating the effects of WBV on bone do not adhere completely to the reporting guidelines for this specific type of studies, especially regarding the calibration and contact of the platform. Following these guidelines could help improving the comparability of WBV studies and identifying the optimal parameters.

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### INCIDENCE OF INJURIES IN ADOLESCENT FEMALE SOCCER PLAYERS: A SYSTEMATIC REVIEW AND META-ANALYSIS.

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UNIVERSITY OF OVIEDO

#### INTRODUCTION:

The popularity among female participation in soccer are growing [1], but in the last decade, this interest is greater in young players from academic to professional soccer league. However, with this growing also the number of injuries [2] among participants has been increasing. Adolescent injuries have high relevance in the actuality, since the rate of injuries is similar to adult players [3]. This is due to the inclusion in



the elite sports professionalization of young players, which requires a elevated training volumes and intensities, since their professional future may depend on it. There are some studies on the incidence of injuries in adolescent women. However, the differences in the methodology, definitions, diagnosis, lost time, or the means of communication, making comparison of results difficult.

**METHODS:**

PubMed/MEDLINE, EMBASE, Web of Science, Scopus and SPORTDiscus (Via EBSCOhost), Cochrane and PEDro databases were searched until July 2020. Included prospective Cohort studies with collected adolescent female soccer injuries data about the incidence, location, tissue type, mechanism and time loss of injuries were included.

**RESULTS:**

The search yielded fifteen studies. The overall incidence of injuries in adolescent female soccer players was 0.15 to 90 injuries/1000 hours of exposure. Lower extremity injuries had the highest incidence percentage (56.5% - 89%). The most common location was knee (16.5% - 74.4%) and ankle (5.1% - 33.5%); the most common types of injuries were joint (Non-bone) and ligament (3.7% - 71.7%) and muscle and tendon (7% - 51%) which were frequently associated with traumatic incidents (17.5% - 86.4%). The time loss most common was minor (1-7 days of time loss) and moderate (8-28 days of time loss) with 28.9% - 71.8% and 23.7% - 88.8% respectively.

**CONCLUSION:**

Adolescent female soccer players have a substantial risk of sustaining injuries, especially in lower extremity (knee and ankle), joint (non-bone), ligament, muscle and tendon, in a traumatic mechanism, with a majority of moderate time loss after the injuries.

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## STATISTICS AND ANALYSES

### INFLUENCE OF GAME LOCATION, TEAM ABILITY, GAME PERIOD AND TECHNIQUE ON SERVE PERFORMANCE IN TOP-LEVEL FEMALE VOLLEYBALL PLAYERS

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**INTRODUCTION:**

The game actions performance is dynamic and unpredictable, especially due to the relationship amongst the players and the influence of contextual variables. In volleyball, the serve performance varies in terms of the quality of opposition and the set played in male category (Marcelino et al., 2012), as well as the serve is a key action for winning in top-level competitions (Peña et al., 2013). Thus, the aim of the study was to analyze the influence of game location, team ability, game period (set) and technique executed on the performance of serve in top-level female volleyball players.

**METHODS:**

A total of 21,327 serves were analyzed during the 496 sets and 132 matches played during the Spanish First League (Liga Iberdrola) in 2017/2018 season. A descriptive design was employed, and the variables were: (a) game location: home or away; (b) team ability: ranking achieved at the end of the league by the serving team (del 1st-4º, 5º-8º, or 9º-12º position); (c) game period (or set): from 1st to 5th set based on game rules; (d) serve technique: standing serve (SS), jump float serve (JF) or jump serve (JS); and (e) serve performance: number of serves, coefficient (mean performance), efficacy (percentage of points) or error (percentage of errors) in serve (García-de-Alcaraz et al., 2016). A normality test, followed by Mann Withney U and Kruskal Wallis tests were done, with a 5% of maximum error allowed. The SPSS 21.0 (Statistical Package for the Social Sciences, SPSS Inc) was used.

**RESULTS:**

The descriptive results showed a prevalence of JF (56,9%), followed by SS (29,1%) and JS (14%). The serve efficacy was a statistically significant higher when teams played at home, and in teams with a higher ranking. The serve performance remains stable along the match, excepting at the fifth set, where the teams showed less efficacy and errors compared to all the previous periods.

**CONCLUSION:**

Also, the most efficacy serve was JS, followed by JF and SS. These findings are useful to coaches, players and researches. This study offers great insights regarding the performance variability of serve in terms of contextual variables and performance execution in women volleyball. Training strategies could be implemented in order to obtain success in competition.

### ANTICIPATION: THE CRUCIAL FEATURE OF A DOMINANT TENNIS PERFORMANCE

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**INTRODUCTION:**

Tennis is a high-paced sport of interception. The ball can reach the receiver at very high speed (from 500ms), creating much pressure for timely reaction. The key to successful performance is identifying the relevant spatio-temporal information in order to infer the future contact point in space ('where') at a specific point in time ('when'). The "when" and "where" are data important to be recognized early (after the contact is sometimes too late) so that the player's movement can be coordinated and balanced in a dynamic environment during the tennis match. In order to satisfy these complex demands, the player is dependent on their ability to perceive the relevant cues and act upon them. The cues are based on contextual information detected through the movement patterns of the opponent before even pertinent postural cues subsequently become available. Elite tennis players possess the ability to perceive visual information from the opponent's movement and use that information to predict the future state of a situation, enabling early initiation of the appropriate reaction for that future state

**METHODS:**

This is an observational study of the tennis match of highest importance (Grand Slam finals), between two professionals for the title match at one of the most prestigious tournaments in tennis history, both players are undoubtedly physically and psychologically at the peak of their performance. They have played almost 50 tennis matches against each other so the factors of tactical advantage and surprise are minimal. The difference between the results of two consecutive sets within the same match should demonstrate that the more successful anticipator between equal opponents will have more chances to win points.

Anticipation was defined as any type of change in body kinetics as an early reaction to identified cues (contextual or postural) of the opponent while the ball is still in flight between the two players (before the opponent's point of impact). The cues are identified by the author

and this identification was based upon the biomechanical laws applied in tennis, qualitative motion analysis and rich tennis experience and knowledge.

#### RESULTS:

The research shows that during a game of crucial importance between two elites, equals in tennis seeded number one and number two, the quality of anticipation (percentage of the total anticipated actions towards the total amount of the identified relevant cues) was a crucial feature of the more dominant performance. In the two consecutive sets of the same match, one player showed fluctuations of successful anticipations which led to winning the first set with ease (Federer – Djokovic set score: 6-1; successful anticipation percentage: 67%-41%; points won 26-12). In the second set however, the difference in the quality of anticipation was much smaller between the players resulting in a much tighter game ending with a tie break (Federer – Djokovic set score: 6-6; successful anticipation percentage: 51%-41%; points won 33-29). At the tie break, the player with the higher percentage of successful anticipation eventually won more points and the set (Federer – Djokovic set score: 6-7, successful anticipation percentage: 38%-44%; points won 4-7)

#### CONCLUSION:

Expert tennis players possess expert abilities to recognize the opponent's patterns of movement earlier, to quickly identify the relevant cues in their visual field, and to add meaning to those cues to coordinate anticipating reactions based on which technical-tactical option is more efficient to generate. These abilities are developed through match experiences but can be enhanced through smart and efficient practice as well. The design of relevant practice methodologies that specifically enhance the perceptive abilities of the player, and the quality of their visual search under dynamic task constraints (due to spatial-temporal pressure), is a prerequisite of creating and nurturing the future champions of our game

### COMPARISON OF MAXIMAL VOLUNTARY CONTRACTION (MVC) AND RATE OF FORCE DEVELOPMENT (RFD) AMONG ATHLETES IN KOREA.

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#### INTRODUCTION:

Athletes need a variety of fitness and skills as they play. For athletes, strength is a very important factor, and the strength of the sports must be quickly responded according to the characteristics of the sport or the situation. The rate of force development (RFD), derived from recorded force or torque time curves during explosive voluntary contraction, have been evaluated to characterize explosive strength of athletes. The purpose of this study is to analyze the Maximal voluntary contraction (MVC) and RFD of South Korea each event athletes and to use it as training data for improving their performance.

#### METHODS:

The subjects were recruited 309 athletes from 11 sports (athletics, badminton, bodybuilding, baseball, bowling, football, golf, korean wrestling (ssireum), swimming, taekwondo, tennis) residing in Jeju Island, South Korea (18.8 ± 3.88 yrs, 170.35 ± 8.99 cm, 63.29 ± 12.20 kg). Test was performed using a horizontal leg-press training machine (Plyo Press, Athletic Republic, USA), it was measured by separating right and left foot, respectively. The seatback was at a 130° angle and the foot was placed in the in a standard position of the leg-press plate. In the ready position, the foot was pressed for up to 3 seconds. MVC and RFD were calculated using a system for muscle performance measurement (Accupower 2.0 software, AMTI, USA). A strain gauge load cell was used to record the force-time curve. To compare group differences, one-way ANOVA and correlation analysis were performed.

#### RESULTS:

In korean wrestling, MVC (L: 309.54±36.75 lbs, R: 322.69±33.11 lbs), RFD (L: 619.36±166.16 lbs/s, R: 532.88±218.35 lbs/s) were the highest, showed significant difference compared to other sports (p<.001). The MVC was then higher in bodybuilding (Lt: 184.94±43.75 lbs, Rt: 183.41±37.94 lbs), football (Lt: 179.56±50.85 lbs, Rt: 183.10±52.96 lbs), taekwondo (Lt: 179.17±44.98 lbs, Rt: 186.02±53.50 lbs). RFD was higher in golf (Lt: 407.64±146.04 lbs/s, Rt: 373.97±171.89 lbs/s) and bodybuilding (Lt: 419.48±104.74 lbs/s, Rt: 407.73±134.74 lbs/s). Post-hoc analysis of RFD showed that the left side was significantly higher Korean wrestling, bodybuilding, golf, soccer, baseball, athletics, taekwondo than swimming, tennis, badminton and bowling. Right side was found wrestling, bodybuilding, taekwondo, golf, athletics, baseball, soccer and bowling were significantly higher than tennis, badminton and swimming. As a result of correlation analysis of MVC and RFD for each event, the Pearson Correlation Coefficients was the highest in golf compared to other sports (Lt: r=.933, p<.001, Rt: r=.893, p<.001).

#### CONCLUSION:

Korean wrestling showed the highest mean of MVC and RFD. Golf had the highest correlation coefficient between MVC and RFD. In the future, detailed analysis will be necessary in consideration of the detailed characteristics of each event sport.

### RELIABILITY OF FIELD-BASED FITNESS TESTS IN ADULTS. THE ADULT-FIT STUDY.

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UNIVERSITY OF CÁDIZ

#### INTRODUCTION:

Physical fitness is a powerful marker of health (1,2), which highlights the necessity of measuring physical fitness to be used in public health monitoring. Field-based fitness tests are time-efficient, low in cost and equipment requirements, and can be easily administered to a large number of people. The objective of this systematic review was to study the reliability of the existing field-based fitness tests intended in adults.

#### METHODS:

A systematic search of two electronic databases (PubMed and Web of Science) was performed up to December 2019 by two independent researchers. Each study was classified as high, low or very low quality according to the description of the participants, the time interval between measurements, the description of the results and the appropriateness of statistics. Three levels of evidence (strong, moderate and limited) were constructed according to the number of studies and the consistency of the findings. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO reference number, CRD42019118480).

#### RESULTS:

From 10,816 eligible studies, 129 original studies were finally analysed. The reliability of tests assessing cardiorespiratory fitness (32 studies, of which 29 were high quality), musculoskeletal fitness (92 studies, of which 78 high quality) and motor fitness (25 studies, all of them high quality) was investigated. There was strong evidence indicating that the 20-m shuttle run, 6-min step and 6-min walk tests are reliable test to estimate cardiorespiratory fitness; handgrip strength, back-leg strength, Biering-Sørensen and prone bridge tests to assess isometric muscular fitness; sit and reach and toe-touch tests to measure flexibility; timed-up-and-go test and t-test for motor fitness. We found moderate evidence that the standing broad jump and pull ups tests is a reliable test to estimate musculoskeletal fitness. Due to the low number of studies, there was limited evidence for a large of other field-based fitness tests.

#### CONCLUSION:

This systematic review provides accumulated evidence supporting that the 20-m shuttle run, 6-min step and 6-min walk tests are reliable tests to estimate cardiorespiratory fitness in adult and; the handgrip test is reliable to assess isometric muscular fitness. However, high quality studies are necessary to assess the reliability of lower body explosive and endurance muscular strength, upper body endurance muscular strength and motor fitness (i.e.: balance and gait speed tests) field-based tests in adults.

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### POSITIONAL PHYSICAL DEMANDS OF NATIONAL TOUCH RUGBY IN A TWO-DAY INTERNATIONAL TEST MATCH SERIES USING GPS PLAYER TRACKING SYSTEM

CHOW, C.C.G.

THE EDUCATION UNIVERSITY OF HONG KONG

#### INTRODUCTION:

Touch rugby is well recognized internationally (e.g. Touch World Cup), it is also adapted to introduce rugby sport to novices of all ages. Touch rugby is a game that the contact components (e.g. ruck, scrum and tackle) are taken out from conventional rugby (i.e. rugby union, rugby sevens and rugby league). The current research would investigate touch rugby which has not been probed a lot. The purpose of this research is to quantify match intensity of the international touch rugby under the rules of Federation of International Touch (FIT).

#### METHODS:

GPS data (18Hz, STATSports, Newry, UK) were collected from 16 Hong Kong national touch rugby players from same team during 3 competition games over a two-day international test match series in Jan 2020. Data were included if the player were selected for the final fourteen player list of each match. The matches were 45 minutes duration each, consisting of two 20 minute halves. Six of the players were playing on the field with unlimited interchange rules. Given the discrete roles, players were grouped into one of three positional groups: Middle, Link and Wing. The 84 GPS data was analysed post game to compare the positional difference on GPS metrics per half. These were total distance covered (m) and six absolute speed zones: zone 1 (0 – 1.5 m/s), zone 2 (1.5 – 3.0 m/s), zone 3 (3.0 – 4.0 m/s), zone 4 (4.0 – 5.5 m/s), zone 5 (5.5 – 6.1 m/s) and zone 6 (> 6.1 m/s). Absolute high speed running (HSR) was the summation of distance covered in zone 5 and 6. Multivariate Analysis of variance and post hoc test were used to compare differences in physical performance variables between positional groups as well as effect sizes expressed as partial  $\eta^2$ . Significant main effects were followed-up by Bonferroni post-hoc procedures. Significance was set at  $P < 0.05$ .

#### RESULTS:

Wings covered longer total distances during match-play than Middle and Link in each half, while the distances were  $1612.91 \pm 513.88$  m,  $1347.50 \pm 316.76$  m,  $1311.35 \pm 223.59$  m, respectively ( $P = .008$ ). There was a significant positional difference on the combined dependent variables,  $F(12, 152) = 7.307$ ,  $P < .001$ ; Wilks'  $\Lambda = .402$ ; partial  $\eta^2 = .366$ . Mean distance covered in zone 1 and zone 2 by Wing were 103.76 m (95% CI, 57.09 to 150.44) and 208.50 m (95%CI, 101.93 to 315.06) longer than mean distance covered by Middle respectively. Meanwhile, they also ran 77.74 m (95% CI, 31.33 to 124.15) with zone 1 speed and 219.30 m (95%CI, 113.43 to 325.36) with zone 2 speed more than that by Link. On the contrary, Wing covered less distance in the relative high intensity running speed (zone 4: 80.46 m, 95%CI, 24.88 to 136.05). No positional difference was found in zone 3 and the HSR zones.

#### CONCLUSION:

Positional differences exist for running demands as speed-based variables. These results give a greater understanding of the physical demands of national touch rugby players and it allows practitioners to quantify the training to align with the intensity recorded within match-play.

### RESEARCH ON PLAYER POSITION AND SIMILARITY OF PLAYER STYLE

QIAN, Z.1, JIN, Q.2

1. TONGJI UNIVERSITY, 2. SHANGHAI CHAMPION INFORMATION TECHNOLOGY

#### INTRODUCTION:

Recent years, although Chinas determination to reform football has been great and its intensity has been strong, the effect is insufficient. It is imperative to return to "technical promotion", analyzing the characteristics of the players, select talents, and promoting the technical revolution of football. The purpose of this article aimed to explore the players position and gain a deeper understanding of the players technical and tactical style, so as to provide a reference for the coach to understand the players reasonable positions on the pitch. In this paper we wish to find abnormal players in the team, the skill distribution of players and players with similar playing skills.

#### METHODS:

The original data of Chinese Football Super League from season 2014 to 2017 provided by Champion Technology Company were analyzed and divided into player data and team data. Players were divided into 4 positions: goalkeeper, forward, midfielder and defender. PAM clustering algorithm was performed using SAS and Python to find abnormal player who does not meet the position setting. Using t-SNE dimensionality reduction technology, players' performance in the season 2014 is displayed in two dimensions so that players style distribution can be obtained. With the help of the DBSCAN clustering method, the midfield players are divided into four categories. By discovering the distance among players in the t-SNE two-dimensional map, we then find the style approximation of players' game technique.

#### RESULTS:

According to the calculation results, players who do not match the clustering results are basically identified in wrong position. There are two main reasons: First, in the Super League, position of the players has been adjusted according to the tactical deployment of the coach, which does not match the reported information of the Football Association; Second, the performance of certain player does not match the

tasks assigned by the coach, which causes problems. Using t-SNE technology, players can be visually displayed in 2D. Except for the position of midfielder, the classification is highly accurate. There are also few player clustering errors. The main reason is that some players have played too few times, resulting in inaccurate clustering. Using DBSCAN clustering method, midfield players are divided into four categories, namely forward players, back players, left forwards and right forwards. This result coincides with the modern football concept, so the model has relatively high credibility. Using t-SNE method in the search for players with similar technical and tactical levels, it can be found that when the Euclidean distance is less than 1, the recommended players have high credibility; when the Euclidean distance is slightly higher than 1, the recommended players have relatively high credibility; when the Euclidean distance is far higher than 1, the recommended players have a certain randomness, which means, low credibility.

CONCLUSION:

## RESEARCH ON PLAYER POSITION AND SIMILARITY OF PLAYER STYLE

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CONCLUSION:

## TRAINING AND TESTING

### ARE DRIBBLING SKILLS IN BASKETBALL RELATED TO EXPERIENCE OF SPORTS, PAST BASKETBALL EXPERIENCE, GENDER AND STANDING HEIGHT?

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1.FUKUOKA UNIVERSITY, JAPAN, 2.HIROSHIMA DRAGONFLIES, JAPAN

INTRODUCTION:

It has been said that skills tests are also very useful for beginners in basketball. In basketball classes, even in a PE major, skills tests are used to measure fundamental basketball skills. However, it seems that the experience of the sport events of students with a PE major sees their specific sports events impact on the measurements of skills tests. In addition, it is only natural that basketball experience, gender, standing height and other factors also influence the measurements. If so, grading should be done while considering these influences. However, as those who belong to the same sports club or category of sports clubs practice the same training or similar training, it cannot be investigated independently. Thus, this study investigates the relationship between basketball skills and various factors using a mixed linear model while taking the relation into consideration.

METHODS:

A dribbling test was administered to 244 university students (71 male and 73 female students) who took a basketball class in the PE department of F-university in Japan. They were asked to dribble around chairs that were set up at an interval of 8 feet long and 6 feet wide each four times. Simultaneously, a questionnaire survey about sports clubs, gender, standing height and the years of basketball experience in elementary, junior high and high school was conducted. Sport clubs were grouped into 5 groups such as "Basketball," "Ball games other than basketball," "Clubs other than ball games," "No club" and "Departments other than PE." A nested structure of the repetition by individual, sports clubs and groups of sports clubs allows us to use a mixed linear model with these as a random effect.

RESULTS:

As the deviance of the model only including the random effect was 4665.1 and the deviance of the model adding the past basketball experience, gender and standing height as a fixed effect was 4557.1, the deviance analysis tells us that the latter model has a good fitness (chi-squared =107.99, df = 5, p<0.001). A significant random effect at the level of 0.1% was found in intra-individual variance (2.20) and sports club (0.92), but was barely significant at the 5% level for groups of sport events (0.36). That is to say, it seems that the dribbling skill is not influenced by groups of sport events so much. In fixed effects, partial regression coefficients of males (that of females has been set to 0),

standing height, and the basketball experience in elementary, junior high school and high school (that of university has been set to 0) were -2.35, -0.05, -0.36, -0.42 and -0.28, respectively.

#### CONCLUSION:

Fundamental basketball dribbling skills after growing up were influenced by training experience in young children as well as by gender and standing height.

### CLASSIFICATION AND PREDICTION OF YOUNG PEOPLE'S REGULAR EXERCISE BASED ON THEIR LIFE-ENVIRONMENT USING A TREE STRUCTURE

ANNOURA, T.1, SAKAGUCHI, H.1, AOYAGI, O.2, NAGAMINE, K.2, CHOI, T.3, HAN, N.3, HONG, T.3, NAM, Y.4, KOO, K.5  
1 JAPAN UNIVERSITY OF ECONOMICS, 2 FUKUOKA UNIVERSITY, 3 JEJU NATIONAL UNIVERSITY, 4 DUKSUNG WOMEN'S UNIVERSITY, 5 CHANGWON NATIONAL UNIVERSITY

#### INTRODUCTION:

The habit of regular exercise in young age is known to bring good psychological and sociological effects and is important for maintaining physical fitness over the whole life and reducing the risk factors for lifestyle-related diseases (Iiboshi, 2002). However, not so many young people do exercise. Therefore, some countermeasures to make them do regular exercise is required. For this, it is essential to discern whether the young people who do regular exercise or not possess what characteristics, environments, sport experience and family structure. However, a traditional multivariate procedure to discern them using scores summing up many weighted variables is not practical. Thus, this study used the decision tree method to perform an assessment in a more practical way with less items that does not require complicated computations.

#### METHODS:

A questionnaire survey was conducted on 404 Japanese N-university students in January, 2018. The questionnaire items consisted of 14 items relating to gender, age, free time in daily life, means of commuting, self-evaluation of one's own physical fitness level, a like or dislike of PE classes in elementary school and family structure. A tree-structure discerned the two groups of exercise and non-exercise with less items of 14 items after tallying data by two groups. A function of rpart() in R was used for analysis and cp (complexity parameter) was set at 0.01.

#### RESULTS:

As a result, a tree-structure with 5 layers and 13 nodes was obtained. The tree structure has nodes with two branches extending right and left according to the responses to each question. The ratio of correct classification was 67.3% (= 272/404). Although specificity that correctly classifies a group of non-exercise into that of non-exercise was 85.3% (=215/252), indicating extremely high, sensitivity that correctly classifies a group of exercise into that of exercise was 37.7% (=57/152), indicating extremely low. That is to say, this tree structure can be said to be an effective model to discern non-exercise. Items used in this tree structure were "Free time on weekends (the number of nodes used = 4)," "Free time on weekdays (3)," "Time to travel to the place to exercise (2)," "Gender (1)," "Age (1)," "Means of commuting to work/study (1)" and "Subjective rating of own physical fitness (1)."

#### CONCLUSION:

Those who do regular exercise had not so much free time but had already decided to do so. On the contrary, those with too much free time did not exercise. Again, those who regularly do exercise had a short travel time to their place to do exercise, were younger than 22 years old, were often male, often used a motorbike to commute to work/study and subjectively thought themselves as fit. However, there was no relationship with "Families who do exercise together," "Like or dislike of PE class in elementary school" and "The purpose to do exercise."

### BIOLOGICAL IMPACT OF AN ENDURANCE RACE OF 64 KM IN COMPARISON WITH SEMI-MARATHON, MARATHON AND A CONTROL GROUP.

LE GOFF, C.

UNIVERSITY HOSPITAL OF LIÈGE

#### INTRODUCTION:

Ultra-marathons are defined as races covering a distance of more than 42.2 kilometers. During the last 10 years, participation in these type of challenge has become increasingly attractive to millions of non-professional endurance athletes worldwide. The aim of this study is to investigate the impact of intense exercise, represented by different endurance races, thank to oxidative stress and cardiac markers.

#### METHODS:

Four populations were compared, a control group of 16 participants "sedentary" (SED) (37,0 ± 4,4 years old), a group of 24 semi-marathon runners (SEMI) (41,0 years ± 8,76 years old), a group of 28 marathon runners (MARA) (44,1 ± 8,4 years old) and a group of 33 ultra-trail runners (UT) (45,8 ± 8,7 years old).

Three blood tests were drawn, one just before, one just after, and the last three hours after the end of the race. Different oxidative stress and cardiac biomarkers were measured on different devices according to the manufacturer specifications.

#### RESULTS:

Myeloperoxidase increased significantly ( $p < 0.0001$ ) during exercise except for SED, but the release is significantly different according to the level of training of the runners. Glutathion oxidized/reduced ratio seems to remain stable during the race except for SED and UT. A significantly decrease in lipidic peroxidation was observed during exercise ( $p < 0.01$ ). We noticed a significantly increase of creatine kinase, isoform MB, myoglobin and C-reactive protein during the race ( $p < 0.0001$ ) and was significantly different according to the race ( $p < 0.0001$ ). We observed a very significant increase of troponin T and natriuretic peptide ( $p < 0.0001$ ) but with a different kinetic than the one obtained for a myocardial infarction.

#### CONCLUSION:

Endurance races provoke the increase of oxidative stress objectified by different biomarkers increase, but a cell necrosis is not specially observed. In fact, the increase of the cardiac markers during endurance races may be explained by a transient modification of myocyte permeability and by micro-muscle damages causing an inflammatory process explaining our observations of markers of inflammation.

### **EFFECT OF A 6-WEEK EXERCISE INTERVENTION FOR IMPROVED NECK MUSCLE STRENGTH IN AMATEUR MALE RUGBY UNION PLAYERS.**

HAMLIN, M.J., DEUCHRASS, R., ELLIOT, C.E., RAJ, T., PROMKEAW, D., PHONTHEE, S.

LINCOLN UNIVERSITY

#### **INTRODUCTION:**

Neck strengthening for players in impact sports like rugby is receiving greater attention lately due to postulated associations with head and neck injury and concussion, and while research is available on the effectiveness of neck strengthening interventions in professional rugby players, the same research has not been conducted on amateurs who make up the majority of rugby players. The aim of this study was to investigate the effectiveness of a 6-week neck strengthening intervention on a group of male amateur rugby union players.

#### **METHODS:**

In a randomised controlled trial, 39 male rugby union players (aged  $20.1 \pm 2.0$  yr, mean  $\pm$  SD), worked with their trainer to practice neck-specific strengthening exercises 3 times per week for 6 weeks (strength group,  $n = 22$ ) or performed no additional neck strengthening exercises (control group,  $n = 17$ ). The neck strength training followed a progressive workload model with the load calculated using the resistance training specific rating of perceived exertion where players adjusted the load lifted according to a 10-point Likert scale. Isometric maximal voluntary contraction (MVC) was measured pre and post the intervention in a seated upright position in 4 different directions (flexion, extension, left and right lateral flexion) via a load cell attached to a head harness.

#### **RESULTS:**

Compared to the control group the strength group improved neck strength in all directions except flexion (flexion  $7.1 \pm 13.0$  kg, mean  $\pm$  SD, 75/18/7%, chances of positive/trivial/negative increase in strength, effect size (ES) = 0.57; extension  $13.5 \pm 14.6$  kg, 92/7/1%, ES = 0.81; left lateral flexion  $13.5 \pm 11.3$  kg, 97/3/0%, ES = 1.21; right lateral flexion  $13.8 \pm 14.9$  kg, 92/7/1%, ES = 0.90. Players undertaking neck strength training improved regardless of whether they were forwards or backs with no clinically relevant difference between the player groups (forwards versus backs).

#### **CONCLUSION:**

Our results indicate that a simple 6-week neck strengthening program improves isometric MVC strength in male amateur rugby union players.

### **RELATIONSHIP BETWEEN WORKING CAPACITY AND ANTHROPOMETRIC, CARDIO-RESPIRATORY AND NERVOUS SYSTEM PARAMETERS IN SOCCER PLAYERS**

OLM, T., BASKIN, K., HERDE, K.

TALLINN UNIVERSITY

#### **INTRODUCTION:**

Sport games, including soccer, are getting faster and faster each year, so the anaerobic working ability of the players is becoming increasingly important in achieving good athletic results. The purpose of this study is to find out which characteristics of the main organ system are related to anaerobic and aerobic working capacities and whether this dependency is similar.

#### **METHODS:**

The subjects were 271 male soccer players of the best clubs of Estonia. Their average age was  $21.5 \pm 3.35$  years. The test battery included anthropometric measurements, electro-, echo- and polycardiography, and incremental treadmill test to volitional exhaustion. Blood lactate concentration (BLa), maximum oxygen uptake ( $VO_2$  max), and the anaerobic threshold (Lactate-4) were recorded. Anticipation speed and correctness, and ability to concentrate were assessed. The ANOVA-test was used. Statistical significance was assumed. Pearson product moment correlation coefficients were calculated.

#### **RESULTS:**

Our complex investigation included 60 anthropometric, cardiovascular, respiratory and nervous system parameters (for each player). Sixteen of them related strongly with anaerobic and twelve with aerobic working time. Correlations are significant at the 0.01 level (2-tailed). The pattern of correlations is different. Only between working times and characteristics of cardio-respiratory systems we can see some similarity of relationships. Anaerobic working time, having strong relationship with 5 main measures of heart, has no significant correlation with anthropometric measurements – in contrast to the aerobic working time. Neither of working times has any significant correlations with the characteristics of nervous system.

#### **CONCLUSION:**

The significant relationship between the anaerobic work abilities and the heart measures lead us to the conviction that in order to properly optimize training loads we need to know not only the functional (ECG, polycardiography) but also the morphological (echocardiography) state of the heart. We reached the same conclusion in [1]. We don't find any statistically remarkable correlation between the complicated characteristics of the nervous system (anticipation speed and correctness, the ability to concentrate) which are most important on sport games, and the characteristics of working ability. This refutes the widespread opinion that the athletes' physical fitness guarantees their mental fitness. The present results show that complex investigations, including echocardiography and nervous system tests, can be useful for identifying the performance level of the players.

#### **References:**

Olm T., Baskin K., Herde K. Age-Specific Features of Soccer Players Heart Dimensions. American Journal of Sports Science. Vol. 5, No. 5, 2017, pp. 27-30.

### **BLOOD FLOW RESTRICTED RESISTANCE TRAINING INDUCE SIMILAR MUSCLE GROWTH COMPARED TO HEAVY RESISTANCE TRAINING, ALTHOUGH DIFFERENT FUNCTIONAL ADAPTATIONS IN TRAINED INDIVIDUALS**

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NORWEGIAN SCHOOL OF SPORTS SCIENCES

#### **INTRODUCTION:**

It is well established that high-load resistance training (HL-RT,  $>70\%/1RM$ ) acutely elevates muscle protein synthesis, and with time augment muscle growth. Evidence from the last decade point to the direction that lower mechanical loads (20-40%/1RM) combined with blood flow restriction (BFR) can acutely elevate muscle protein synthesis and augment muscle growth to a similar extent (1). The increased muscle mass stem from repeated exercise sessions with an accompanied functional adaptation response. Depending on the specific exer-

cise modality, resistance training can lead to enhanced strength, power and/or local muscular endurance. However, these functional adaptations in response to BFR-RT compared to HL-RT are less known. Thus, we aim to elucidate some of the functional adaptations induced by BFR-RT compared to HL-RT.

#### METHODS:

21 strength trained males/females (24±3y) were randomly allocated to perform 9 weeks of strength training (3/week) with either BFR-RT or HL-RT. Before and after the intervention, m. quadriceps cross-sectional area (CSA) was measured with magnetic resonance imaging (MRI) and total lean leg mass was quantified with dual-energy X-ray absorptiometry (DEXA). Furthermore, functional adaptations were measured by maximal voluntary contraction (MVC) force of the knee extensors on an isokinetic dynamometer, maximal jump height using a squat jump (SJ) technique on a force-platform and local muscular endurance using a 50 repetition maximum fatigue test on an isokinetic dynamometer.

#### RESULTS:

Quadriceps CSA increased with BFR-RT (6.8±4.3% .003) and HL-RT (4.7±2.9% .007) with no differences between groups (.296). Total lean leg mass increased with BFR-RT (1.9±1.8% .004) and HL-RT (1.0±1.3% .041) with no differences between groups (.184). HL-RT increased MVC (9.7±12.2% .030) while no changes was observed after BFR-RT (5.2±12.9% .28), no group interaction (.416). HL-RT increased SJ height (7.2±8.8cm .020) while no changes was observed after BFR-RT (-0.14±7.3cm .874), no group interaction (.067). Moreover, HL-RT did not increase performance on the fatigue test (2.6±11.8% .399) while BFR-RT increased performance (10.8±8.1), significant group interaction was observed (.000).

#### CONCLUSION:

Overall, these data further support the application of BFR-RT to induce hypertrophic adaptations comparable to HL-RT. However, although similar muscle growth was observed, our data suggests that the functional adaptations occurring from the contrasting training modalities may differ. This might be related to the principle of specificity regarding the two different training protocols. Consequently, BFR-RT seems to be a novel approach to muscle hypertrophy, while inducing different functional adaptations than HL-RT in trained individuals.

1 Fry et al., 2010

## THE EFFECT OF 8-WEEK CORE STABILITY TRAINING ON LUMBOPELVIC MOTOR CONTROL IN YOUNG RHYTHMIC GYM-NASTS

CABREJAS, C., SOLANA, M., MORALES, J.

BLANQUERNA, RAMON LLULL UNIVERSITY

#### INTRODUCTION:

Lumbopelvic motor control (LPMC) and core stability training (CST) are associated with low back pain (LBP) and injury prevention (Panjabi, 1992; Akuthota et al., 2008). Nevertheless, little is known about the relation with sports performance improvement (McGill, 2010). Recent studies have questioned the benefits of CST for athletic performance (Reed et al., 2012). Therefore, the aim of this study is to observe the effect of 8-week CST on LPMC in young rhythmic gymnasts.

#### METHODS:

A convenience sample of 42 young female rhythmic gymnasts from a competitive team (age = 10.5 ± 1.8 years, height = 144.1 ± 10.6 cm, weight 38.2 ± 8.9 kg, BMI = 18.2 ± 2.2m/kg<sup>2</sup>) participated in the study. The subjects were randomized divided in control group (CG) and experimental group (EG). Pre-test, post-test design was used. The LPMC was assessed by the bent knee fall out (BKFO) and the active straight leg raise (ASLR) tests. The EG (n=23) followed an eight-week CST program while the CG (n=19) received the common training session. Statistical analysis was performed with the Statistical Package for Social Sciences version 25.0 (SPSS, Inc., Chicago, IL). The Shapiro-Wilks test was used to evaluate the normal distribution of the data. Mixed model ANOVA [group (experimental and control) x time (pre- and post-test)] was applied to assess the effects of the training program on LPMC. Finally, Bonferroni post-hoc tests were performed and a significance level of p < 0.05 was used for all tests.

#### RESULTS:

There was found a significant main effect on the time variable in BKFO-D (F<sub>1,39</sub>=5.13; p=0.029) and BKFO-I (F<sub>1,39</sub>=4.08; p=0.049). There were no effects on the ASLR tests and no interaction effect (time x group). Pairwise comparisons showed significant results (p < 0.05) better in the experimental group in the post-tests of BKFO-D (mean = 6.85 ABSΔmmHg) and BKFO-I (mean = 9.49 ABSΔmmHg) compared to the pre- BKFO-D (mean = 10.52 ABSΔmmHg) and BKFO-I (mean = 12.28 ABSΔmmHg) tests. The control group and the ASLR test showed no differences in any case.

#### CONCLUSION:

According to our study the EG has improved the LPMC in the lower extremity oblique plane movements. There were no differences in the sagittal plane. This suggests that the Rhythmic Gymnasts are used to train static balance rising their legs in different shapes; however, they are not used to the leg rotatory movements. Therefore, this specific core training can help to improve the dynamic balance and turns in young rhythmic gymnasts.

## FACTORS THAT CAUSE TIME DELAYS IN SOCCER PASSES

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#### INTRODUCTION:

In a soccer game the ball can change direction instantly when an opponent enters the pass of the ball. At the time of this sudden exchange, two situations may develop the pass the player initiated may succeed, but a pass mistake is also possible, and it is this kick mistake that will be observed. A study that examined the change in kick direction was conducted by Van der Kamp (2006). He found that a player is able to change the kick direction if the discrimination time is at least 400 milliseconds (ms). Thus, the action to change the direction of a kick takes time. However, this study did not clarify the characteristics of the action. A study of the pass was made by Ma Jian (2010) and was also examined in this survey, but it too does not clarify the causes of actual pass mistakes. The purpose of this study was to reproduce a pass observed in a recorded game in a laboratory and to elucidate the factors that cause a delay in passes.

#### METHODS:

Ten right-footed male participants (21.4 ± 0.5 yrs.) took part in the experiment. They had played football for, on average, 10 yrs. When a participant traps a ball and performs an inside kick in the direction of the goal a LED light on the upper goal post turns on. In the task of activating the LED lighting from random attempts under multiple experiment conditions observed a series of motions before and after the

kick. There are four incident points related to the kick: 1) no change, 2) in front of the trap, 3) after the trap, and 4) just before the kick. Participants performed a single task and multiple tasks related to these incident points. The data analysis included: 1) MT (time to kick from a trap), 2) the pass success rate, and 3) a motion analysis. The direction angle of the kick was obtained from the participants hip joint and the target goal, and analyzed.

#### RESULTS:

Comparing the MTs of the single task and the multiple task (CM), the CM was found to be significantly longer by 61 ms ( $p < 0.05$ ), and the pass success rate was about 10%, significantly lower than in the single task. In the motion analysis, when the angle at the time of the kick was compared with standard deviations, the variation in the angle of the CM was about 3 degrees, which was significant.

#### CONCLUSION:

The pass delay was due to the fact that the difficulty of the pass had increased because the conditional tests were performed randomly in the multiple task. This change in difficulty manifests as an increase in kick time and dispersion created by the motion. It was found that this change in the kick motion led to an increase in pass mistakes.

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### **THE EFFECTS OF UNEQUALED VOLUME UNILATERAL, BILATERAL AND COMBINED LOWER BODY RESISTANCE TRAINING ON MUSCULAR STRENGTH, POWER AND SPEED**

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#### INTRODUCTION:

Currently, many methods of resistance training exist that causes many fitness practitioners have a lot of ways to train themselves or their clients. One of the long known methods is the unilateral and bilateral ways of performing the exercise. Bilateral exercises share resistance between two limbs. It is a movement that is produced by two limbs at the same time. Bilateral exercises work both sides of the body, meaning both limbs share the stress. Unilateral movement is a movement that is produced by one limb. Unilateral exercises only place stress on one limb that is being used for the exercise. This study was conducted to compare the effects of unequaled loading of unilateral, bilateral and combined lower body resistance training on muscular strength, power and speed.

#### METHODS:

Forty-five recreationally active, resistance trained men (age:  $21.84 \pm 2.41$  years old) were recruited and divided into Unilateral Group (UG;  $n = 15$ ), Bilateral Group (BG;  $n = 15$ ) and combined Unilateral and Bilateral Group (UBG;  $n = 15$ ). Participants involved in a six weeks supervised lower body resistance training intervention, twice per week. Participants need to lift 80% of their 1RM of leg press and leg curl exercises during the training sessions. Each exercise was performed for four sets. The UG performed both exercises unilaterally for four sets each, while BG performed both exercises bilaterally for all the four sets. UBG perform two sets unilaterally and another two sets bilaterally for each exercises. The 80% of 1RM were based on the unilateral and bilateral scores thus making the training program to be unequaled in terms of loading. 1RM for unilateral and bilateral leg press and leg curl exercises, vertical jump and 30m sprint tests were conducted before and after the training intervention. Mixed analysis of variances (ANOVA) was used to compare the effects of the training intervention within and between the groups.

#### RESULTS:

Results showed that all the three groups managed to improve in all the tests during the post-test. UG and UBG were found to have greater improvement in 1RM for unilateral leg press and leg curl and 30m sprint test while BG and UBG were found to have greater improvement in 1RM bilateral leg press and leg curl exercises and vertical jump test.

#### CONCLUSION:

Despite the bilateral methods allowed greater loads to be lifted, it was found that muscular strength, power and speed adaptation were more influenced by the types of training performed. Bilateral strength and power that were performed bilaterally in this test were shown to be better if the training was conducted bilaterally. On the other hand, unilateral strength and speed that were performed unilaterally were shown to better if the training was conducted unilaterally. The findings of this study demonstrate the important of performing exercises using both unilateral and bilateral methods for maximizing physical abilities.

### **CHANGES IN CYCLING PERFORMANCE AFTER TWO DIFFERENT HIGH-INTENSITY INTERVAL TRAINING PROTOCOLS USING THE POWER LOSS AS A VARIABLE FOR CONTROLLING THE TRAINING LOAD: A MULTIPLE CASE-STUDY**

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#### INTRODUCTION:

The total time expended near to  $VO_{2max}$  during high-intensity interval training (HIIT) has been proposed as a way for programming the number of intervals completed during each HIIT session (1). However, this method is not a feasible way to control HIIT training out of laboratory conditions. The relationship between external and internal training loads has been widely studied in cycling (2). Measuring the loss of power during HIIT intervals could be a way for programming and controlling HIIT training in cycling. We hypothesized that it could exist a relationship between the number of intervals completed during HIIT training and the power loss during each interval. Thus, the aim of this pilot study was to evaluate the influence of two different HIIT training interventions (10% power loss vs 20% power loss) in cycling performance and training load.

#### METHODS:

Six trained cyclists ( $VO_{2max}=58.99 \pm 2.08$ ) were randomized into two different HIIT groups (G10% loss ( $n=3$ ) and G20% loss ( $n=3$ )). Each group completed 8-wks of training (15 HIIT sessions). Cycling performance was evaluated before and after training intervention using an incremental exercise test ( $VO_{2max}$ , PPO, WVT1, WVT2), time to exhaustion test (P5, P12, P20) and critical power (CP). HIIT training was programmed using the power output at  $VO_{2max}$  (PPO). Each subject performed "n" intervals at PPO until the power loss intervals were equal to 10% or 20%.

#### RESULTS:

Although the low sample size limited any statistical analysis, no significant differences were found in the variables studied ( $p > 0.05$ ). However, effect size analysis revealed possible changes in cycling performance (P5, P12, P20, CP) after training intervention ( $ES = 0.7-2.1$ ).



VO<sub>2</sub>max showed a positive change in both groups after training (ES G10%=1.3; ES G20%=1.3). The training load measured as training stress score (TSS) and total intervals completed (TIC) was 54.27% and 8.78% higher respectively in the G20% group.

**CONCLUSION:**

This investigation reports that using the power loss for programming and controlling the number of intervals to complete during HIIT session, might be a reasonable variable in order to improve cycling performance which allows optimizing and individualizing the total training load completed by each cyclist. The mechanisms proposed which could explain the improvements in sport performance after HIIT programs comprises increments in VO<sub>2</sub>max (3). Although the present study did not find differences in VO<sub>2</sub>max after training between groups, individual data showed a positive trend in both groups in this variable.

**LONGITUDINAL STRENGTH DEVELOPMENT OF ELITE ADOLESCENT RUGBY UNION PLAYERS BY PLAYING POSITION**

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**INTRODUCTION:**

The development of an elite rugby union player requires years of physical preparation. Increased knowledge of the long-term physical development of junior players can aid in improving Long Term Player Development (LTPD) pathways, subsequently resulting in maximising long term playing performance, while minimising the risk of injury among players (1). The purpose of this investigation was to observe strength development in elite adolescent rugby union players over time, compare differences in this development by position, and estimate individual differences between players within positional units, during the final two years of their junior competitive career.

**METHODS:**

Fifteen elite adolescent rugby union players (8 forwards, 7 backs) (age, 18.0 ± 0.2 y; body mass, 93 ± 13 kg; height, 185 ± 9 cm) were selected from a provincial academy in Ireland to participate in this study. Anthropometric measures (body mass, stature) and three strength parameters (box squat, bench press, chin-up) were assessed over two years. Mixed modeling was used to assess strength development over time and differences between positional units.

**RESULTS:**

There was an overall increase in box squat (1.0, ±0.5; standardised increase, ±90%CL: most likely substantial), bench press (0.8, ±0.2: most likely substantial) and chin-up (0.6, ±0.6: likely substantial) strength. Small differences in these changes over time were observed for bench press (0.3, ±0.4: possibly substantial) and chin-up (0.5, ±0.5: likely substantial) strength, with forwards outperforming backs. Post-hoc analysis revealed large individual differences in the changes in box squat (0.8, ±0.2; standardized standard deviation, ±90%CL: most likely substantial) and chin-up strength (0.8, ±0.1: most likely substantial) for both forwards and backs, and moderate-sized individual differences for the changes in bench press strength (0.5, ±0.2: very likely substantial).

**CONCLUSION:**

Substantial improvements in strength can be expected over an annual period for elite adolescent rugby union players, with small differences in development presenting between positional units. Practitioners should also expect moderate- to large-sized individual differences within strength development over time.

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**TALENT DETERMINANTS OF YOUNG OPEN WATER SWIMMERS: A SYSTEMATIC REVIEW**

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**INTRODUCTION:**

Although talent determinants of young swimmers were well documented in the literature, still few studies were found on the talent detection of young swimmers in open water. Furthermore, as for the difference of the competition environment, intensity, and the requirements for the physical function between the competitions in open water and in the swimming pool, the event specialized talent determinants should be established for the young open water swimmers. The objective of study is to explore the talent determinants of young open water swimmers.

**METHODS:**

This systematic review was conducted under the guidance of Preferred Reporting Guidance of Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) criteria. Articles published after 2009 were searched from Pubmed, Web of Science, EBSCO and CNKI (Chinese database). 47 articles were included and the information of the age of study population, indexes for measuring talents, results for the evidence of the relationships between the indexes of talents and performance of athletes were retrieved for the systematic review.

**RESULTS:**

Consistent evidence were shows that in addition to the body streamline index, maximum oxygen uptake, the proportions of different skeletal fiber types, sense of water were ascertained as important talent determinants for young swimmers in common with other swimming events, indexes of sense of direction, sense of rhythm, flexibility, will power should also be treated as event specialized talent determinants for young open area swimmers. Of note, it was controversial in the literature for using the Angiotensin Conversion Enzymes (ACE) gene as a talent detection assessment for young open area swimmers.

**CONCLUSION:**

For the talent detection of young open area swimmers, the body streamline index, maximum oxygen uptake, the proportions of different skeletal fiber types, sense of water, sense of direction, sense of rhythm, flexibility and will power were most important indexes that should be considered, while the role of ACE gene was controversial and need to be further studied.

**INTERCOSTAL MUSCLES OXYGENATION DURING A MAXIMAL INCREMENTAL EXERCISE IN MALE AND FEMALE: DIFFERENCE BETWEEN GROUPS**

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**INTRODUCTION:**

In similar exercise intensities, females have more work of breathing (WOB) than males, attributed to differences in respiratory mechanics due to anatomical aspects 1. This phenomenon increases when the minute ventilation (VE) exceeding  $\pm 70\%$  of breathing reserve 2. The WOB has recently been recorded by a portables device using near-infrared spectroscopy principle (NIRS) that evaluates the level of oxygen muscle saturation (SmO<sub>2</sub>) in the superficial respiratory muscles (m.intercostales) 3. The main objective was to compare the SmO<sub>2</sub>-m.intercostales of male and female at different intensities of an incremental exercise protocol (rest, VT1, VT2, VO<sub>2</sub>-máx), and to evaluate the association with ventilatory variables (VE, respiratory rate (RR), and tidal volume (Vt)).

#### METHODS:

Seventeen healthy subjects active physically (8 females) performed the protocol in cycle ergometer (ViaSPRINT 1500, Ergoline, Germany). We registered VE, RR and Vt breath-by-breath method. Respiratory gases (Master Screen, Jaeger, Germany) were measured continuously during the protocol. The SmO<sub>2</sub>-m.intercostales was evaluated throughout the exercise with the Moxy monitor device, positioned in the anterior axillary line in seventh right intercostal space. The protocol consisted of 1-min rest, exercise phase to 30 watts initial and progressive increase 15 watts per minute until obtaining detentions criteria. The participants were keeping a 70 – 90 rpm cadences. A one-way ANOVA and posteriori Dunnett tests were used to detect changes intragroup, and two-way ANOVA for comparing groups. Significance was set at  $p < 0.05$ . The statistical analysis was using Graph-pad Prism software 8.0.

#### RESULTS:

The SmO<sub>2</sub>-m.intercostales were different between male and female groups at rest and VO<sub>2</sub>-max. phase  $p < 0.001$  and  $p = 0.009$ , respectively. Females have significant differences between rest and VT2 ( $p < 0.001$ ). Respect to associations with SmO<sub>2</sub>-m.intercostales, VE showed a positive correlation in female ( $r = 0.69$ ,  $p = 0.005$ ) and men ( $r = 0.89$ ,  $p < 0.001$ ). The RR showed a positive correlation in the female group ( $r = 0.72$ ,  $p = 0.004$ ) and Vt in the men group ( $r = 0.88$ ,  $p = 0.001$ ).

#### CONCLUSION:

We conclude that SmO<sub>2</sub>-m.intercostales at a maximal intensity of exercise decreased in men and female at similar values ( $\pm 30\%$  respect to rest), but showed differences changes respect to changes in ventilatory variables. In Females were associated with increases in RR, while in males with increases in Vt. New investigations are motivated to evaluate the impact of respiratory muscle training on the SmO<sub>2</sub>-m.intercostales and the impact on exercise performance.

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### DOES INSPIRATORY MUSCLE TRAINING CHANGE AEROBIC CAPACITY IN YOUNG FOOTBALL PLAYERS?

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#### INTRODUCTION:

Inspiratory muscle training (IMT) is used in several programs of pulmonary rehabilitation with good results. However for sports performance, results are yet scarce and in football no studies were found.

The purpose of our study was to verify if an exercise training program for inspiratory muscles with eight weeks of duration will influence inspiratory muscle strength (IMS) and cardiorespiratory capacity (VO<sub>2</sub>).

#### METHODS:

Twenty two healthy sports participants from a youth sub-19 football team were invited and after a first assessment (M1), allocated in a randomized way in three groups: RTTG (Respiratory and Task Training Group; n=8), RTG (Respiratory Training Group, n=7) and CG (Control Group, n=7). Assessment protocol included inspiratory muscle strength (IMS), anthropometric measures and estimated maximal oxygen consumption (VO<sub>2</sub>) by yo-yo test. They were assessed at three moments: M1 – after vacations at the pre-season, at M2 – after one month of football training and at beginning of inspiratory muscle training (IMT) and M3 – after eight weeks of IMT with an IMT device (Power-Breath) and normal football training. IMT was performed at 60% of maximal strength, in 5 to 6 sets of twelve repetitions (one minute between sets). For RTTG a technical task from football training was added during the IMT.

#### RESULTS:

Differences were observed between M1 and M2, M2 and M3 for three groups, in IMS, showing an increment in muscle strength. Results for VO<sub>2</sub> showed that IMT seems to change VO<sub>2</sub> only for RTTG and RTG since VO<sub>2</sub> does not change significantly between M2 and M3 for CG.

#### CONCLUSION:

An IMT program of 8 weeks and at 60% of maximal strength additionally to the normal sports training seems to change IMS and VO<sub>2</sub> and this could influence positively game performance of young football athletes.

### EFFECTS OF A ONE-WEEK DIVING INTERVENTION IN THE BODY COMPOSITION OF HEALTHY YOUNG ADULTS

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#### INTRODUCTION:

Scuba-Diving is considered as a recreational sport with positive effects in stress management and well-being [1]. However, the neutral buoyancy during the dive leads to mechanical unloading in the human body comparable to zero gravity, which induces changes in muscle structure as well as muscle strength [2]. This study aims to describe the changes in the body composition of healthy young adults during a one-week diving intervention.

#### METHODS:

12 healthy subjects were recruited for this study (4 female, 8 male,  $23 \pm 3$ y,  $178 \pm 9$ cm,  $75 \pm 12$ kg). The intervention consisted of 6 dives in a period of 5 days in  $< 10$ m depths, which lasted approximately 15min. On the second day a training intervention consisting of multiple counter drop jumps was scheduled. Body weight (BW), Skeletal muscle mass (SMM), absolute body fat (BF) and relative body fat (BF%) was measured via bioelectrical-impedance analysis (BIA, InBody770) before (pre) and after (post) the intervention. Participants were told to fasten 12 hours and not to drink anything 8 hours before the measurement. This was done in underwear without any metal on the body to ensure valid measurement. Body mass index (BMI) and fat free mass (FFM) was also calculated. Significance was set at 0.05. Mean differ-

ences were tested with the independent t-test (SMM, BMI and BF) or the Wilcoxon-Test if the parameter was not normally distributed (BW, BF%).

#### RESULTS:

SMM significantly changed during the intervention, SMM (Pre: 35.7±11.9; Post: 36.1±7.8, p=0.02). BW (Pre: 74.7±11.9; Post: 74.9±11.8, p=0.1), BF (Pre: 11.7±5.3; Post: 11.5±5.2, p=0.366), BF% (Pre: 16±2.1; Post: 15.7±7.0, p=0.338) BMI (Pre: 23.5±2.1; Post: 23.6±2.1, p=0.59) and FFM (Pre: 63±12.9; Post: 63.5±12.8) did not change significantly.

#### CONCLUSION:

The data suggest a significant gain in SMM by an average of 0.35kg. Doing the training intervention could be a possible explanation for the gain, but most of the participants were trained athletes in which such a gain is not expected. The procedure of carrying the equipment to the dock, walking with the gear, which weights approximately 23kg, could also induce a training stimulus. However, the SEM for InBody770 for fat-free mass was stated as less than 0.84kg, which could explain the increase in SMM [3]. In conclusion, the data postulates no significant change in BW, BF, BF% and BMI but a gain in SMM. To attribute the changes in SMM to diving more research with a bigger sample size has to be done to further elaborate this topic.

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### TISSUE CONTENT DEPENDENT PHYSIOLOGICAL RESPONSE AFTER AEROBIC AND ANAEROBIC EXERCISES IN YOUNG MAN

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#### INTRODUCTION:

Overweight (OW) and obesity (OB) are often associated with low levels of physical activity. Physical activity is recommended to reduce excess body weight, prevent body weight regain, and decrease the subsequent risks of developing metabolic and orthopedic conditions. However, the impact of OW and OB and on the other hand increased muscle mass with low body fat on aerobic and anaerobic performance in case of young man is still not fully understood. The aim of this work was to assess the impact of body proportion on physical performance in case of maximum anaerobic power, maximum power, power drop and VO<sub>2</sub>max.

#### METHODS:

Three populations were analyzed: twenty three well trained man with high concentration of muscle tissue (PAM) aged 20.2±1.2 years, 18 physically non-active men with higher BMI and fatty tissue concentration (PNAM) aged 19.9±1.0 years and 15 non-training man with normal BMI and fatty tissue concentration aged 20.1±1.7 years. All of them performed lower body 30s Wingate Tests and Bruce test to measure maximal anaerobic and aerobic capacity. For anaerobic power of the lower limbs, Wingate anaerobic test (WANt) was conducted on a cycle ergometer (Monark894E, Peak Bike from Sweden). Data from the cycle ergometer was recorded via computer with the MCE 5.1 software. Following WANt variables was analyzed: total work value (W<sub>tot</sub>), maximum anaerobic power (PPWANt), maximum power (TUZ), maximum power maintenance (TUT) to 0.01s, power drop (WSM) (%). For maximal aerobic capacity whole population performed a Bruce treadmill test under a mixing-chamber-gas-analyzer-ergospirometry (Jaeger Oxycon Pro, Viasys Healthcare, Germany) for measurement of VO<sub>2</sub>max.

#### RESULTS:

A significant differences were observed in whole population with the relationship to the body fat content. Results observed in anaerobic conditions showed direct correlation with muscle mass and reverse correlation with body fat content.

#### CONCLUSION:

Specific physiological response was dependent from the fatty, and muscle tissue content and it correlates with the severity of the inflammatory response.

The project is financed by the National Science Centre, Poland (2018/29/N/NZ7/02800).

### TECHNICAL CHANGE IN DRIBBLING SKILL IMPROVEMENT OF PRESCHOOL SOCCER PLAYERS

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#### INTRODUCTION:

The purpose of this study is to clarify the technical change in dribbling skill improvement of preschool soccer players.

#### METHODS:

Subjects were 26 preschool children; 13 in the training group (TR), and 13 in the control group (CONT). Both groups have a 1 hour training once a week. For the first 30 min TR did dribbling training (DRI-TR). While CONT did tag and kick training. After each training, both groups followed interpersonal training such as 1 vs 1 and mini game. Both groups did these training performed for 6 months. The dribbling and sprinting tests were carried out before each group's training, after 2 months and after 6 months. The items measured in the dribbling test were Total Time, Time of each phase, ball operation part and number of ball touches and missed touches in third phase, average and standard deviation of the maximum of the distance between ball kick foot toe and center of the ball of every ball touch in third phase, and Time in the sprinting test.

#### RESULTS:

The results showed that Time in the sprinting test decreased significantly for both groups after 2 months and after 6 months. But Total Time and Time in third phase of the dribbling test showed significant decrease only in TR after 2 months and after 6 months. The TR's standard deviation of the maximum distance between ball and toe in third phase for the TR also decreased significantly after 6 months. Furthermore, the TR's number of ball touches, missed touches and standard deviation of the maximum distance between ball and toe in third phase also decreased significantly after 2 months and after 6 months.

#### CONCLUSION:

Consequently, this study clarified that 6 months' DRI-TR for 6 months intended for preschool soccer players caused not only improvement in sprinting speed but also improvement in the skill to keep stably and control the ball within their foot's reach.

## **FITNESS EVALUATION IN YOUNG AND AMATEUR SOCCER PLAYERS: REFERENCE VALUES FOR VERTICAL JUMP AND AEROBIC FITNESS IN MEN AND WOMEN.**

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### **INTRODUCTION:**

The evaluation of the physical condition is essential for being able to apply the results to the individual training planning. Vertical jump measurement has been a recurring assessment in the evaluation of physical condition in soccer players during the last decades, especially through CMJ (1). This test has demonstrated great validity and reliability (2), even in children (3). In the same way, VO<sub>2</sub>max estimation from indirect field tests is a commonly used strategy in the evaluation of physical condition in soccer players. Among these, the Leger & Lambert test (4) stands out, which has been used multiple times for this purpose (5) and it has a high correlation between the maximum speed reached in the test (maximum aerobic velocity) and the VO<sub>2</sub>max ( $r = 0.84$ ). Therefore, the main objective of this study was to assess the physical condition of young and amateur soccer players.

### **METHODS:**

362 soccer players (14.86±3.18 years; 1.66±0.14 meters; 56.62±12.91 kg) from 19 different teams participated in the study. The extensor strength of lower limbs was evaluated using a countermovement jump (CMJ) measured by the MyJump2 iOS app (6) and the aerobic fitness was tested through the incremental run Leger test. Subsequently, the differences between the results of the different tests were analyzed according to gender (male and female), category (senior, U19, U16 and U14), position (goalkeeper, central defender, full back, midfielder, winger and striker) and competitive level (national, regional and local).

### **RESULTS:**

Statistically significant differences ( $p < 0.05$ ) were found in both tests according to gender and category. The results of the women's teams in CMJ and Leger test are significantly lower than those of the men's teams. The competitive level was also a discriminatory variable in U19 and U14 categories for both tests. The highest competitive players obtained the best results both in CMJ and in the Leger test. The analysis based on the position did not show significant differences in the CMJ. However, in the Leger test, fullbacks ( $p = 0.043$ ), midfielders ( $p = 0.018$ ) and wingers ( $p = 0.019$ ) obtained better results than the goalkeepers.

### **CONCLUSION:**

The assessment of physical fitness in soccer, and especially the measurement of vertical jump and the aerobic fitness, has aroused considerable interest in recent years. As a result we can find numerous studies that address this issue in samples with elite male players in senior (7) and U19 categories (8) but much less in young, amateur or female. The results of the CMJ and Leger tests in young and amateur soccer players must be analyzed individually, using specific reference values according to gender, category, position and competitive level, due to the differences found based on these variables.

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## **AUTONOMIC RESPONSE OVER A SHORT CROSSFIT TRAINING IN ELITE ATHLETES.**

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### **INTRODUCTION:**

CrossFit is based in high intensity interval training (HIIT) using varied movements, attracting people of different skills and ages. CrossFit spreads fast in last decade, inducing researchers to study about it (1–4). However, some physiological responses over CrossFit athletes remaining unknown. This study aimed to describe the heart rate variability (HRV) and training load responses in elite CrossFit athletes following a short training period.

### **METHODS:**

Nine elite athletes participated in this study. A well known training called "FRAN" was used. The values for R-R interval (iR-R) were analyzed during a week before the training starts and at the day of training: i) five minutes before the training and; ii) five minutes after the training. The HRV utilized the Ultra-Short-Term method (i.e., two minutes in rest). Training load was measured using the Rating Perceived Exertion (RPE) and Training Impulse (TRIMP). The present study investigated the physiological effects of a well-known CrossFit training named as WOD "Fran" in nine elite CrossFit men athletes, on HRV, WOD time and training load in arbitrary units (AU). All athletes were in tapering phase. Athletes characteristics are exposed in table 1. The participants number follows studies with similar design (25–27). The complexity to recruit elite athletes is evident. All the subjects provided written informed consent, and all study methods and protocols were approved in advance by the Research Ethics Committee of the School of Physical Education and Sport of Ribeirão Preto/USP (CAAE: 13353719.4.0000.5659).

### **RESULTS:**

The main finding was: (i) significant decrease in HRV modulation comparing basal values to 5 minutes before the training (RR), basal to 5 minutes after the training (LnRMSSD, RR) and 5 minutes before the training to 5 minutes after training (LnRSMSSD, RR and LF), ( $p < 0,05$ ). Moreover, HR increased comparing basal to 5 minutes before and 5 minutes after training ( $p < 0,01$ ). (ii) Training load was high and it showed similar results in the athletes that done the training in similar time. We confirmed the hypothesis that elite CrossFit athletes in short training decrease HRV variables (excluding HR) and training RPE over 80% of intensity. Furthermore, the study found high training load (TRIMP) in the athletes, possibly due its high intensity.

### **CONCLUSION:**

In conclusion, we can infer from our data that a short CrossFit training is enough to change significantly the autonomic responses, leading to fatigue immediately after training. Also, CrossFit based on specific training demonstrated higher training load, when compared to other activities using similar time.

## **VALIDITY AND RELIABILITY OF A NEW 30-SECOND, NON-MOTORISED TREADMILL TEST**

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### **INTRODUCTION:**

The Wingate 30-second cycle test is the most common, valid and reliable assessment of anaerobic capacity [1]. Non-motorised treadmills have also been developed to assess anaerobic capacity with peak and mean power during a 10-second sprint shown to exhibit similar reliability to the traditional 30-second Wingate test [2]. However, no validity comparison was conducted, possibly due to the different time intervals. Subsequently, the aim of this study was to assess the validity and reliability of a newly developed 30-second running protocol on a non-motorised treadmill.

#### METHODS:

Eleven (1 female, 10 male) young, healthy, active adults volunteered and completed one Wingate 30-second cycle test and two, 30-second non-motorised treadmill sprints in a randomised order over three weeks. Participants completed one test per week following a standardised warm-up. For the 30-second Wingate test, participants cycled as fast as possible on a MONARK ergometer with a workload of 0.085 kg per kg of body mass [3]. For the 30-second, non-motorised treadmill tests, participants ran tethered on a WOODWAY treadmill with a running belt resistance of 0.18 kg per kg of body mass [4]. Peak and mean velocity (treadmill only), peak and mean power, total work, distance covered (treadmill only), peak heart rate, peak rating of perceived exercise and peak blood lactate were recorded during tests. Validity of the new non-motorised protocol was determined via Wilcoxon tests while reliability was determined by Wilcoxon tests, intra-class correlation coefficients, coefficient of variation, measurement bias/ratio and 95% limits of agreement [5,6].

#### RESULTS:

Compared to the 30-second Wingate test, the non-motorised treadmill tests resulted in significantly greater peak power (~27%) and heart rate (~3%), significantly lower mean power (~10%) and total work (~10%), and similar rating of perceived effort and lactate. Repetitive performances of the 30-second, non-motorised treadmill test produced similar results except for a significantly lower peak blood lactate for the second test (20.8 vs. 19.3 mmol/L). The intraclass correlation coefficients were significant and >0.6 for all variables except mean velocity (0.440) and distance covered (0.436). The coefficients of variation were 2.0-9.2% for all variables while the biases were small.

#### CONCLUSION:

This study demonstrated that the 30-second, non-motorised treadmill tests produced significantly different results to that of the traditional 30-second Wingate test, potentially due to differences in muscle mass and workload employed. The 30-second, non-motorised treadmill test was confirmed as a reliable protocol in young, healthy, active adults.

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### THE RELATIONSHIP BETWEEN THE FLUCTUATION OF UPS AND DOWNS AND VARIOUS FACTORS ON 2-POINT SHOOTING DURING A WHOLE SEASON AMONG JAPANESE PROFESSIONAL BASKETBALL PLAYERS

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#### INTRODUCTION:

Comprehending the fluctuation of ups and downs of each player's performance in basketball games can be helpful when used by a team on its own players or when scouting other teams. Among them, it is said that the fluctuation of ups and downs on 2-point shooting (2P), which is shot in various ways, greatly affects the outcomes of games. Thus, this study aimed to investigate the relationship between the fluctuation of ups and downs and various factors in 2-point shooting during a whole season among Japanese professional basketball players.

#### METHODS:

The subjects were 178 professional basketball players who belong to the Japanese B-League and who played more than 30 games. Multiple regression analysis was conducted using a successful ratio (SR) of 2P as a dependent variable and the degree of 1 to 5 of the order of games as an independent variable. Curves of the degree that showed a significant difference were drawn within the range concerned. Judging from the shape, the following types were categorized: the "Upward" and "Downward" types that increase or decrease linearly, the "Stable" type that has one a peak or trough, and the "Unstable" type that has two or more peaks or troughs. To clarify the association between these types and various factors such as BMI, standing height, body weight, assists, turn-overs and the Efficiency Index, a two-way ANOVA was conducted by type.

#### RESULTS:

Significant differences were found in 33 curves in total. In the association between the peak-and-trough type and various factors, a significant relationship was found in standing height ( $F_0 = 7.844$ ,  $df = [1, 30]$ ,  $p = 0.009$ ), body weight ( $F_0 = 4.916$ ,  $df = [1, 30]$ ,  $p = 0.030$ ), assist ( $F_0 = 15.360$ ,  $df = [1, 30]$ ,  $p < 0.001$ ), and turn-over ( $F_0 = 15.360$ ,  $df = [1, 30]$ ,  $p < 0.001$ ), indicating that the SR of players who are tall, heavy, and have few assists and turn-overs increases. In addition, significant interaction was found in assists ( $F_0 = 3.537$ ,  $df = [1, 30]$ ,  $p = 0.0013$ ) and the SR of those who have few assists increased in "Unstable" type.

However, no significant difference was found in BMI and the Efficiency Index. In short, physical factors, such as standing height and body weight, and basketball skills, such as assists and turn-overs, have an impact on the fluctuation of ups and downs in 2P during a whole season.

#### CONCLUSION:

As the reason why the SR of players whose standing height or body weight is excellent increases during a whole season, it can be explained by the fact that standing height and body weight can constantly be maintained over a whole season when compared with skills or physical fitness that are characterized by their low reliability and unstableness. In regards to the result that those who have few assists and turn-overs maintained a strong SR, it seems that because assists and turn-overs are passive plays based on the game situation that cannot be predicted, if they play while considering them, those players lose their own style of play and lose their good condition.

### APPLICATION OF THE MONARK894E ERGOMETER IN ANAEROBIC POWER TEST - RESEARCH ON THE EFFECTS OF RESISTANCE COEFFICIENT AND STARTING MODES ON THE WINGATE ANAEROBIC POWER TEST

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#### INTRODUCTION:

The Wingate anaerobic power test is one of the classical test methods used to evaluate anaerobic capacity. When conducting the 30-second Wingate anaerobic power test, it is essential to specify detailed values for resistance, times of evaluation, and the type of starting mode to accurately reflect the unique characteristics and physical requirements of the subject's sports.

#### METHODS:

The subjects in this study are 10 male speed skaters selected from the China Men's Speed Skating Team, ages  $18.2 \pm 2.78$  with heights of  $173.7 \pm 2.63$  cm and weights of  $65.5 \pm 5.38$  kg. The study seeks to evaluate: 1. The difference between resistance coefficients of 10% and 8% of the body weight while using a constant starting mode of applying resistance once the subject has reached maximum pedal frequency, and 2. The difference between starting modes while using a constant resistance coefficient of 10% of the body weight as follows: one with no resistance applied until the subject has reached maximum pedal frequency, at which moment the resistance load is applied, the timer starts, and the subject's heart rate is recorded; the other one begins in a standing pose, with the resistance load applied immediately as the subject begins to pedal. The peak and the average power are compared and analyzed. The warm-up consists with cycling with a 60-80W load for 10 minutes, including three 6-second sprints. The test starts after a 5-minute rest. In this study, the Swedish Monark894E ergometer test system with software version 3.3.0.0 is used.

**RESULTS:**

1. When varying the starting modes from the maximum pedal frequency start to the standing start mode while the resistance coefficient is consistent at 10% of the subject's body weight, the peak powers are  $825.99 \pm 148.08$ W and  $1082.58 \pm 141.1$ W respectively, with a correlation coefficient of  $r=0.851$ . The average power over 30-second is  $647.19 \pm 108.42$ W and  $747.32 \pm 97.5$ Ws respectively, with a correlation coefficient of  $r=0.962$ . There was no significant difference.

2. When varying the resistance coefficient from 10% to 8% of the subject's body weight with a constant starting mode at a maximum pedal frequency start, the peak powers are  $825.99 \pm 148.08$ W and  $754.23 \pm 110.85$ W respectively, with a correlation coefficient of  $r=0.911$ . The 30-second average power is  $647.19 \pm 108.42$ W and  $585.47 \pm 91.13$ W respectively, with a correlation coefficient of  $r=0.971$ . There was no significant difference.

**CONCLUSION:**

1. In the anaerobic test, the peak power and the average power of the mode with consistent loading resistance are found to be both higher than the measured value of the reloading resistance when the maximum pedal frequency is reached.

2. The result of Monark894E ergometer indicates that the influence of the resistance coefficient on the anaerobic power test is less significant than that of the starting mode.

Keywords: Wingate anaerobic power, resistance coefficient, starting mode, peak power

**SYSTEMIC APPROACH OF FENCING PERFORMANCE IN COMPETITION: STUDY ON ELITE COMPETITORS**

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**INTRODUCTION:**

Fencing is an open-skill combat sport practiced with three different weapons contested with different rules. Characterization of performance during competition involves many scientific disciplines. It is of high interest to better understand performance and to contribute to define more efficient training applications.

Excepted isolated initiatives, very few studies have addressed physiological and psychological aspects during competition jointly with the match follow-up. This lack of knowledge thus leaves place for empiricism for the fencer preparation. Most training situations take place outside of a specific connection with competitive reality without ecological approach and individual adaptation.

Following a preliminary study done in U20 international fencers during 6 national level competitions, the aim of this study is to explore in Elite fencers the possible relationships between physiological states assessed by heart rate and lactatemia and psychological states during performance in a competitive context.

**METHODS:**

Following the same protocol of the previous study, 33 fencers (members of the French National Team) participated to the study during 6 national level competitions in adult category involving a selection issue, one for each weapon and gender (foil, epee, sabre x male and female). Lactates were determined from 20  $\mu$ l of capillary blood. Heart rate was registered all day long with a heart rate monitor. Psychological states include perceived stress, perceived activation, perceived fatigue, and perceived stake and were rated with 10 cm visual analogic scales. Measures were done when arrival on site, at the end of warm-up, before and after each match during the pool phase (only before and after the whole pool for the psychological data), and before and after each match during the direct elimination phase. A log book of the matches (time, duration, pauses, score evolution) was written for each participant.

Multivariate analysis were done including contextual variables (part of the competition, part of match, opponent, state of score...).

**RESULTS:**

Analyses are presented according to weapon and gender. Examples of fencer typologies are presented, independently of weapon and gender. Heart rate and lactatemia study confirm a wide range of energetic processes used in fencing competition. These variables are not necessary linked with psychological states like stress or motivation for example.

**CONCLUSION:**

Whether results confirm that competitive fencing uses wide range of energetic processes, they do not allow to characterize specific weapon x gender typology. However, individual typologies emerge irrespective of weapon or gender. Moreover, significant relationships between contextual, physiological and psychological states may highlight and reinforce necessity to favor personalized and contextualized training.

Although practicing each weapon is clearly identified, it may appear that individual characteristics cannot be clearly associated with one specific weapon

**DIFFERENCES IN MUSCLE VOLUMES AND SPRINT PERFORMANCE BETWEEN HIGH-LEVEL SPRINTERS AND YOUNG ACTIVES**

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**INTRODUCTION:**

Sprint ability is a key factor in many sports and hence the focus of many training programmes. Many factors could influence the sprint ability although power production seems the most important. In this sense, the power production a muscle can generate is directly related with its volume. Large muscles will produce more power, but to a certain extent since increases in volumes would increase the segment moment of inertia and hence reductions in segment's angular acceleration for a given joint torque. The aim of the study is to elucidate differences of quadriceps and hamstrings muscle volumes between high-level sprinters and young active population.

**METHODS:**

Seven national-level sprinters and nine sports sciences students took part in the study. The sport sciences students were physically very active ( $8 \pm 3$  hours of training/week). In order to exclude differences in body composition and body segments sizes that could affect the interpretation of thigh muscle volumes, an anthropometric analyses was done (Table 1). Muscle volumes were calculated from a series of Resonance Magnetic Imaging of the thighs. The edges of rectus femoris (RF), vastus medialis (VM), vastus lateralis + vastus intermedius (VLI), biceps femoris long head (BF<sub>lh</sub>), biceps femoris short head (BF<sub>sh</sub>), semitendinosus (ST) and semimembranosus (SM) were manually outlined image-by-image in the range of 288 images in order to get the three-dimensional volume with minimum error of measurement. Sprint performance was measured analysing the instantaneous velocity during a 40m dash by a radar gun where 10m and 40m time and maximal velocity (V<sub>0</sub>) were extrapolated.

**RESULTS:**

Sprinters showed larger muscle volumes than actives of RF (26%  $P < 0.05$ ), VEI (13%  $P < 0.05$ ), VM (24%  $P < 0.05$ ), BF<sub>lh</sub> (25%  $P < 0.01$ ), ST (35%  $P < 0.01$ ) and SM (37%  $P < 0.01$ ). BF<sub>sh</sub> showed no difference between groups (Figure 1). These differences in muscle volumes give us information about sprint training adaptations: the bi-articular muscles and, specially, the hamstrings are disproportionately larger in sprinters probably due to the dual role they have in these activity. Regarding sprint performance, sprinters had higher V<sub>0</sub> (20%  $P < 0.01$ ) and were faster in 10 m (7%  $P < 0.01$ ) and 40m (11%  $P < 0.01$ ) than actives. Hamstrings muscle volume showed moderate to strong correlations with sprint performance. Interestingly, as longer was the sprint distance higher was the association, until V<sub>0</sub> where we found the higher correlations.

**CONCLUSION:**

Sprinters showed increased hamstrings and quadriceps muscle volumes compared with the young non-specialized athletes although the anthropometrically similarities between groups. These disproportionately incremented hamstrings compared with quadriceps give us information regarding the crucial role of the hamstrings in sprinting. The strong correlations between hamstrings muscle volume and sprint performance elucidate the importance of this muscle group in this activity.

### **EFFECT OF A SIMULTANEOUS APPLICATION OF ISCHEMIC PRECONDITIONING AND PLACEBO ON ISOMETRIC STRENGTH OF LOWER LIMBS**

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**INTRODUCTION:**

Ischemic preconditioning (IPC) is a noninvasive intermittent local ischemia-reperfusion intervention performed on the subjects limb, during short time, with evidences of performance enhancement. Extensively tested under exercise conditions, mainly due its low cost and feasibility, although a physiological pathway is still lacking. Its recent results reinforce a predominant heterogeneity mainly linked to the use of also varied protocols (1). In addition, there is also the possibility of an IPC-placebo effect, highlighting a plausible explanation for the absence of physiological changes. The placebo effect in sport can be defined as a neurobiological response that promotes performance improvement, as a consequence of inert sham treatment (2). In this sense, this study aims to test the simultaneous application of IPC and placebo (SHAM) on knee extension maximal voluntary isometric contraction (MVIC).

**METHODS:**

Nine healthy and young men ( $22.44 \pm 3.36$  yrs;  $176.67 \pm 5.50$  cm;  $74.66 \pm 5.65$  kg;  $11.76 \pm 4.19$  body fat %) participated of this study. Following the baseline tests, subjects performed unilateral MVIC after IPC on right and SHAM on left thigh. Following 48 hours, the subjects performed another set with the opposite-limb (IPC and SHAM) applications, which allowed each subject to serve as his own control. Occlusion cuffs (96 x 13 cm) were placed at the proximal upper thigh of the subject and were inflated to 50 mmHg above systolic arterial blood pressure for 5 min and repeated three times (i. e., 3 x 5 min occlusion/5 min reperfusion) for IPC intervention whereas for SHAM the cuff was inflated to only 20 mmHg. Both IPC/SHAM were performed interspersed on the subject thigh, totalizing 30 min of intervention. To equalize cognitive appraisal of intervention and avoid/minimize nocebo effect, subjects were informed about the testing of two external pressure conditions and that both could improve performance.

**RESULTS:**

Comparisons were made between conditions for the right or left thigh x baseline tests. Significant reduction between conditions were observed for left thigh on MVIC [Baseline:  $968.7 \pm 125.2$ ; IPC:  $865.2 \pm 130.2$ , ( $p=0.010$ ); SHAM:  $873.0 \pm 125.6$  N, ( $p=0.004$ )], but not for right thigh [Baseline:  $1050.0 \pm 116.3$ ; IPC:  $968.5 \pm 139.8$ , ( $p=0.101$ ); SHAM:  $1022.0 \pm 145.3$  N, ( $p=0.999$ )].

**CONCLUSION:**

The IPC or SHAM intervention did not improve MVIC knee extension performance on both thighs. These results may favor the assumption that exercise improvements after IPC, previous observed, could be mediated by a central placebo effect, but not caused by a local ergogenic agent.

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