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External Load in Elite Youth Soccer Players According to Age Category and Playing Position in Official International Matches

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Abstract

Background/Objectives: To compare the external load (EL) of elite youth soccer players during official international matches between age categories and playing positions. **Methods**: The sample consisted of 42 elite youth soccer players categorized by age categories, U-15, U-17 and U-20 and playing positions: central defender (CD); fullback (FB); midfielder (MF); wide attacker (WA) and striker (ST). The Vector X7 (Catapult Sports) device was used for collecting the following EL variables: total distance traveled (TD), player load (PL) and distance traveled per velocity band 0 to 7 km/h (D7); 7 to 13 km/h (D13); 13 to 19 km/h (D19); 19 to 23 km/h (D23) and >23 km/h (HSR). Linear mixed-effect models were applied to analyze the differences. **Results**: Large differences were found between positions ($p < 0.01$) in TD ($\eta^2p = 0.48$), PL ($\eta^2p = 0.30$), D19 ($\eta^2p = 0.44$), D23 ($\eta^2p = 0.68$) and HSR ($\eta^2p = 0.53$). Large differences were found according to category between U-15 and U-17 in TD ($p = 0.006$ and $\eta^2p = 0.25$) and D13 ($p = 0.003$ and $\eta^2p = 0.27$). Large interaction effects were found in DT ($p = 0.014$ and $\eta^2p = 0.44$) and D23 ($p = 0.002$ and $\eta^2p = 0.51$). **Conclusions:** This study concludes that there are differences in EL in official matches in elite youth players between age categories and playing position. These differences can be applied in practice to design individualized training by playing position and to monitor EL during microcycles.

Keywords: contextual factor; displacement; kinematic; football; match running performance; team sport

1. Introduction

Physical fitness has become an increasingly decisive factor in modern soccer, playing a fundamental role in both individual player performance and team effectiveness [1,2]. Consequently, quantifying the physical demands to which players are exposed during training and official competitions—commonly referred to as external load (EL) [3,4]—has become essential for scheduling training within microcycles. To this end, the use of global positioning systems (GPS) has become widespread, providing a valid and reliable means of collecting spatiotemporal data as well as information on linear and rotational velocity change [5–7]. Such information is critical for optimizing technical–tactical and physical training, informing the planning and prescription of training loads and serving as a valuable tool for monitoring fatigue and recovery processes [8–10], and during matches, it has become important to analyze physical profiles by playing position and differences between athletic levels and use this same load as a reference to distribute loads during the microcycle [2,11–13], which is why its quantification becomes important for technical teams.

The ELs of adult male professional soccer players are exposed during official matches is widely described in the literature, as well as the usefulness of these metrics for both performance and injury prevention [14–16]. However, there are fewer studies that analyze the ELs of youth soccer players during official competitions [7,17,18]. Considering youth soccer players are in the process of biological maturation, there are physical and anthropometric differences that can influence the amount and intensity of efforts during competition [19–21]. One study showed that the EL was similar between first division and U-19 players; except for the distance covered at maximum speed during a friendly match [4], these results do not represent the reality of the physical requirements of younger categories due to a more advanced biological maturation by U-19 players [22]. In addition, the requirement of a friendly match is lower compared to an official competition [23]. Therefore, knowing the demands of elite players of different age categories can help teams have parameters for quantifying the load during training to avoid fatigue on match days and to have EL parameters during matches in order to detect potential talents or weaknesses to be trained in players who are not meeting the physical demands of the match [8–10].

At the same time, the EL is influenced by the position of the players on the pitch and the formation of play in official competitions [24]. Some studies have analyzed the EL between playing positions of different categories of young players; for example, a systematic review found similar results in the studies reviewed, highlighting that central defenders cover less total distance and in high intensity than the other positions and wider attackers and midfielders cover more distances in high intensity [17], but more recent studies in young amateur players (two workouts per week) found no differences between positions [25], so the level of the athletes may influence the analysis. These differences could be help to staff for perform specific physical and technical–tactical drills training by game position.

In summary, although the evidence on external load (EL) in youth national team squads is still scarce, the available studies indicate that biological development and tactical demands according to playing position model differential profiles of high-speed distance, sprints, accelerations/decelerations and maximum speed [12,26–28]. Therefore, comparing EL in official competition between age categories and playing positions in international competition will allow us to create specific development trajectories and guide decisions on training programming and talent promotion. Based on this framework, we propose that older age categories will present higher values per minute in total distance and high intensity running, with more pronounced increases in fullbacks and forwards compared to central defenders and central midfielders.

2. Materials and Methods

2.1. Sample

A non-probabilistic convenience sampling was conducted, consisting of 42 elite young football players from a selection team from a South American country (Chile). The sample included three age categories: U-15 (n = 13; age = 15.3 ± 0.3 years; body mass = 66 ± 7.5 kg; height = 1.72 ± 0.08. m), U-17 (n = 15; age = 17 ± 0.5 years; body mass = 71 ± 9 kg; height = 1.76 ± 0.08 m) and U-20 (n = 14; age = 18.9 ± 0.3 years; body mass = 78 ± 12 kg; height = 1.76 ± 0.06 m). Players were classified according to their playing position: central defenders (CD), full-backs (FB), midfielders (MF), strikers (ST) and wide attackers (WA). Observations were included only when players participated in matches for more than 60 min (corresponding to 67% match time approximately) because of existing differences between players who played less than 60 min in relative terms, meaning the analysis could be biased [18].

2.2. Procedures

Data collection took place during a South American tournament for each category in 2019, recording information from all the matches played by each group. The category U-15 (34 observations) and U-20 (34 observations) played 4 matches and the category U-17 played 9 matches (76 observations). It is important to note that the training regime prior to international competitions consisted of 6 training days per week, with sessions lasting 90 to 120 min. During the tournament, matches were held every 48 h, with training conducted in a single 90 min session, focusing on recovery and tactical organization. The study was carried out in accordance with the ethical standards established in the Declaration of Helsinki [29], and due to the nature of the data (retrospective and common monitoring), ethical approval and signatures for the informed consent form were not required [30]; nevertheless, all data were kept anonymous for analyses to ensure subject confidentiality.

2.3. Instruments

To assess the ELs of the subjects during the competition, the Vector X7 device (Catapult Sports, Melbourne, Australia) was used, which has GPS (10 Hz), 3D accelerometer (1 kHz) and a gyroscope (100 Hz). All the players were familiar with the measuring instrument due to its constant use during training and competitions. GPS with a frequency of 10 Hz has proven to be valid and reliable for measuring running performance during competitions adequately [31]. The device was inserted into a neoprene vest placed firmly between the scapulae to collect metrics. All data were collected through the Vector Core software (V6.10) for further analysis.

2.4. Data Processing

A total of 144 observations were analyzed (34 observations of U-15 and U-17 and 76 observations of U-20). The variables analyzed were total distance traveled (TD), player load (PL); distance between 0 and 7 km/h (D7); distance between 7 and 13 km/h (D13); distance between 13 and 19 km/h (D19), distance between 19 and 23 km/h (D23) and high-speed runs >23 km/h (HSR). These velocity bands are widely reported in football studies, which facilitates comparison/discussion between studies [32–34]. All the variables were normalized by the minutes of competition during each match. Data processing was carried out in Excel spreadsheet (version 2411, Microsoft, Redmond, WA, USA).

2.5. Statistical Analysis

The normality of the data was analyzed through the Kolmogorov–Smirnov test and histograms, where the assumption of normality ($p > 0.05$) was assumed. Descriptive statistics were presented as mean and standard deviation. To analyze the difference between factors, we fitted linear mixed-effects models with external load variables as the dependent variable, Positions, Category, and their interaction as fixed effects, and random intercepts for players due the assumptions violation of repeated measures (or independent observation). The model was estimated using the lme4 package [35] (Bates et al., 2015) in RStudio (version 2024. 12.1 +563), and *p*-values for fixed effects were obtained from type II Wald chi-square tests in combination with lmerTest [36] and effect sizes were calculated as partial eta squared (η^2p). The categorization of the effect size was trivial ≤ 0.01; small between 0.01 and 0.06; moderate between 0.06 and 0.14 and large ≥ 0.14 [37]. When main or interaction effects were found, post hoc tests were carried out with Tukey's correction and only the differences between positions of the same age category and playing position between age categories were presented. The alpha level was set at 0.05.

3. Results

Table 1 presents the descriptive and inferential statistics of the groups by age category and interaction. Large differences were found according to category between U-15 and U-17 in TD ($p = 0.006$ and η^2p = 0.25) and D13 ($p = 0.003$ and η^2p = 0.27). Large interaction effects were found in DT ($p = 0.014$ and η^2p = 0.44) and D23 ($p = 0.002$ and η^2p = 0.51). Post hoc comparisons of interaction effects are in Figures 1 and 2.

Table 1. Descriptive values for category and interaction statistics.

	U-15		U-17		U-20		Category		Interaction	
Variables	**M**	**±SD**	**M**	**±SD**	**M**	**±SD**	***p***	**η^2p**	***p***	**η^2p**
TD (m/min)	98.8 *	9.87	105	10.7	103	9.03	**0.006**	**0.25**	**0.014**	**0.44**
PL (UA/min)	9.76	1.00	9.82	1.789	10.1	1.48	0.524	0.03	0.390	0.25
D7 (m/min)	39.9	3.61	38.0	30.4	38.6	2.17	0.088	0.15	0.709	0.19
D13 (m/min)	42.9 *	7.06	49.2	8.09	46.6	7.11	**0.003**	**0.27**	0.058	0.39
D19 (m/min)	10.9	3.22	12.5	3.92	12.3	3.73	0.054	0.13	0.277	0.28
D23 (m/min)	3.88	1.42	4.12	1.33	4.12	1.01	0.400	0.08	**0.002**	**0.51**
HSR (m/min)	1.08	0.77	1.24	0.72	1.51	0.95	0.440	0.06	0.610	0.22

Bold values are $p < 0.05$; * difference vs. U17 $p < 0.05$; M, mean; SD, standard deviation; η^2p, partial eta squared; TD, total distance; PL, player load; D7, total distance between 0 and 7 km/h; D13, total distance between 7 and 13 km/h; D19, total distance between 13 and 19 km/h; D23, total distance between 19 and 23 km/h; HSR, high-speed running >23 km/h.

Table 2 shows the descriptive statistics between playing positions and comparison between positions. Large differences were found between positions ($p < 0.001$) in TD (η^2p = 0.48), PL (η^2p = 0.30), D19 (η^2p = 0.44), D23 (η^2p = 0.68) and HSR (η^2p = 0.53).

Table 2. Descriptive values for positions and inferential statistics.

	Central Defender		Fullback		Midfielder		Striker		Wide Attacker		Position	
Variables	**M**	**±SD**	**M**	**±SD**	**M**	**±SD**	**M**	**±SD**	**M**	**±SD**	***p***	**η^2p**
TD (m/min)	94.6 ^{M,S,W}	6.74	100	5.80	108	10.3	110	10.2	106	11.1	**<0.001**	**0.48**
PL (UA/min)	8.80 ^{M}	1.47	9.55	1.17	10.9	1.44	10.2	1.05	10.0	1.50	**0.020**	**0.30**

Table 2. *Cont.*

	Central Defender		Fullback		Midfielder		Striker		Wide Attacker		Position	
Variables	M	±SD	M	±SD	M	±SD	M	±SD	M	±SD	p	η^2p
D7 (m/min)	39.3	2.86	38.3	2.31	37.3	3.87	39.7	2.38	39.3	2.73	0.710	0.08
D13 (m/min)	42.6	5.41	45.9	4.10	51.5	9.13	48.9	7.99	47.3	9.63	0.053	0.27
D19 (m/min)	8.81 ^{M,W}	2.05	10.9	2.01	14.9	4.06	13.9	2.68	12.8	3.43	**<0.001**	**0.44**
D23 (m/min)	2.91 *	0.77	3.97 ^{W}	1.02	4.15 ^{W}	1.17	5.37	1.18	4.95	1.09	**<0.001**	**0.68**
HSR (m/min)	0.94 ^{W}	0.496	1.295	0.75	0.80 ^{S,W}	0.56	2.17	0.554	1.91	0.85	**<0.001**	**0.53**

Bold values are $p < 0.05$. * Differences with all positions $p < 0.05$. M difference with midfielder $p < 0.05$. W difference with wide attacker $p < 0.05$. S difference with striker $p < 0.05$. M, mean; SD, standard deviation; η^2p, partial eta squared; TD, total distance; PL, player load; D7, total distance between 0 and 7 km/h; D13, total distance between 7 and 13 km/h; D19, total distance between 13 and 19 km/h; D23, total distance between 19 and 23 km/h; HSR, high-speed running >23 km/h.

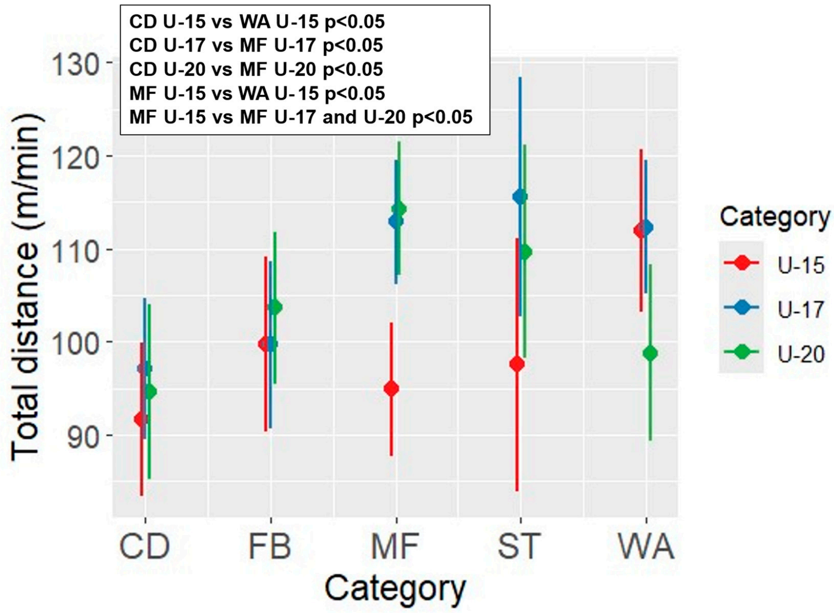

Figure 1. Plot of position values by age category and post hoc comparisons in Total Distance. CD, central defenders; FB, full-backs; MF, midfielders; ST, strikers; WA, wide attackers.

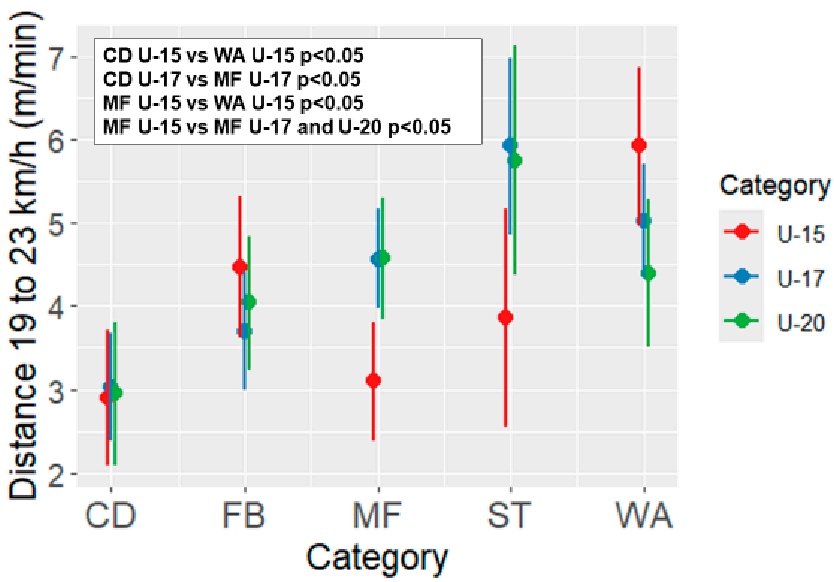

Figure 2. Plot of position values by age category and post hoc comparisons in distance between 19 and 23 km/h. CD, central defenders; FB, full-backs; MF, midfielders; ST, strikers; WA, wide attackers.

4. Discussion

Quantifying EL is essential due to the physical demands and stress associated with training and competition [9,10]. However, few studies have examined the external load of youth soccer players during their transition to professional levels in official competitions. The primary objective of this study was to identify differences in external load among elite youth soccer players during official matches. The results of this study provide valuable information on the physical demands placed on elite young soccer players, revealing significant differences by age category and playing position during an official international competition.

The results indicate that the U-17 category recorded the highest TD values per minute, showing a significant difference and a high effect size compared to the U-15 category. This finding suggests that the increase in competitive demands between 15 and 17 years of age is crucial. However, the U-20 category did not show a linear improvement compared to the U-17 category, even presenting slightly lower TD values. This suggests that, once a certain physical maturity is reached, the demands of competition are more influenced by the tactical context, the level of the opponent, or technical instructions than by chronological age [38].

This result contrasts partially with the findings of Palucci Vieira et al. [17], who report a progressive increase in total distance with age (from U-13 to U-18). The present results qualify this view by suggesting that the progression is not linear at the most advanced elite levels (U-20), where contextual factors may attenuate age differences. This stabilization of performance is consistent with Slimani & Nikolaidis [39], who indicate that abilities such as speed and agility show their most significant improvements until adolescence, stabilizing thereafter. The absence of differences in distances at high speed (HSR >23 km/h) between categories reinforces the idea that game speed stabilizes in advanced youth categories, as age differences are less evident when using individualized thresholds or adjusting effective playing time [17].

Position has various statistical differences, showing large effects on almost all variables, except for D7 and D13. The results confirm the traditional profile reported in the literature [17,40,41], with CD covering significantly less TD and less distance at high intensity (D19, D23, HSR) than the other positions, which is consistent with the clear positional specialization in young people previously reported [42]. In contrast, MF, ST and WA showed the most demanding physical requirements. A relevant finding that expands on previous work was the profile of ST and WA, who recorded the highest values in very high speed (D23 and HSR). This not only confirms that offensive players perform the most sprints [17], but also quantifies this demand in specific speed zones, underscoring the need for training focused on sprinting ability and explosive actions for these players [39].

The most revealing finding of the study is the presence of significant large-effect interactions between age category and playing position for key variables such as TD and D23. This indicates that the evolution of physical demands with age is not uniform for all positions. The results suggest that, for example, the performance gap between a U-15 and U-20 center back may be smaller than that observed between a U-15 and U-20 midfielder. Furthermore, it could be interpreted that FB or WA may experience the greatest physical development between the ages of 17 and 20, while others stabilize earlier. This finding goes beyond the conclusions of previous studies [17,39] that describe differences by age and position separately. The interaction found is crucial for coaching staff, as it implies that training programs must be specific, considering not only the player's position but also their stage of development within that position. A single load model for an age category would be inadequate.

This need for specificity aligns with Bradley & Ade [40] who argue that traditional physical metrics alone are insufficient to capture the complexity of performance and advocate for an integrated approach that contextualizes physical data with tactical purpose.

4.1. Limitations

This study has limitations that should be considered when interpreting its results. First, the use of non-probability convenience sampling from a single national selection limits the generalizability of the findings to other populations of elite youth soccer players. Additionally, the absence of data on the biological maturation status of the participants, a crucial factor in this population, makes it impossible to discern whether the differences observed are strictly due to chronological age or level of maturity [43]. Furthermore, contextual factors such as team tactics, opponent quality and game status were not controlled for, which could act as confounding variables [38].

4.2. Future Projections

Future research should focus on creating larger, multicenter samples that include players from different soccer contexts to improve external validity. It is imperative to incorporate the assessment of biological maturation (e.g., Peak Height Velocity) for a more accurate understanding of physical development. It is also recommended to systematically analyze the impact of contextual and tactical variables on external load. Finally, longitudinal designs that follow athletes throughout their development would represent a significant advance in establishing individual trajectories.

4.3. Practical Implications

These differences can be used in practical terms to create individualized playing-position training programs; for example, some playing positions could benefit from intermittent high-intensity training (HIIT) of different types, like short or repeated sprint training (see [44,45]), depending on the position and/or to monitor loads during microcycles.

5. Conclusions

In conclusion, this study shows that the external load in elite young soccer players varies significantly depending on age category and playing position, with a crucial interaction between both factors. The findings indicate that physical demands do not increase linearly with age, but rather appear to stabilize in higher categories, while positional specialization in high-intensity actions is evident from an early age. The interaction found underscores that the evolution of demands with age is not uniform for all positions, highlighting the critical need to individualize training programs considering both the position and the specific stage of development of the athlete. Precautions should be taken when generalizing our results due to the type of sampling and origin of the sample, and because it is only a selection team, that factor (tactics, biological maturation, sex, quality of the opponent) can influence these values.

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