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Effects of Experimental Volleyball Rules Quantified by Type and Number of Jumps, Hits and Contacts

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ABSTRACT

The purpose of this study was to determine the influence of the two new rules tested at the inaugural U23 Men's Volleyball World Championship (21-point set excluding the fifth set, and 15 seconds between rallies–10 seconds from the finished point until the referee's whistle for serve and five seconds for performing the serve) on number and types of jumps and number of contacts and hits. The analysis comprised 25,930 jumps (an essential physical activity for volleyball), 15,706 contacts and 10,224 hits during 36 matches played by 144 males aged under 23 at the first Under 23 Men's World Championships organized in Uberlandia, Brazil, in 2013. Two investigations were conducted: 1) Analysis of jumps by Jump type, In-game role and Level of set win; 2) Analysis of contacts (reception, setting, block, defense) and hits (serve and attack) by Type, In-game role and Set outcome. Significant differences ($p=0.000$) were found between in-game role and jump type, as Middle blocker performed the most (34.7%), followed by Outside hitter (24.9%), Setter (24.6%) and Opposite (15.8%). Significant differences were found for number and types of Hits between set Winner and Loser teams only for serves by Setter ($p<0.001$) and Middle blocker ($p<0.05$). The results showed major differences in jumps, hits and contacts between in-game roles: Middle blocker was the most frequent jumping position, followed by Outside hitter and Setter. The Libero showed a new tendency of being Setter with a jump after the initial Setter defense.

Key words: in-game role, libero, setting, attack, block

Introduction

Volleyball has become a very popular sport played in many countries worldwide (Aouadi et al., 2012; Sheppard et al., 2008; Sheppard et al., 2011). Throughout the history of volleyball the rules have been modified to make it a more exciting spectator sport (Ureña, Gallardo, Delgado, Hernández, & Calvo, 2000). The changes tested by Fédération Internationale de Volleyball (FIVB) during the first Under 23 (U23) Men's World Championship, in 2013, were intended to modernize volleyball and make it more appealing for fans attending matches or watching games on television (FIVB, 2013c). Two of the main characteristics of volleyball are the jump and the specific types of contact with the ball.

Investigations into players' ability to reach upwards, attack frequently from height and achieve a high blocking position showed that jumping is an important athletic skill for high performance in volleyball (Aouadi et al., 2012; Borràs, Balias, Drobnic, & Galilea, 2011; Marcelino & Mesquita, 2008; Sheppard, Gabbett, & Taylor, 2007; Sheppard et al., 2008; Vilamitjana et al., 2008). The attack and block, as important actions of a volleyball game, were identified as the best predictors in matches (Afonso, Esteves, Araújo, Thomas, & Mesquita, 2012; Castro & Mesquita, 2008; Marcelino & Mesquita, 2006; Marcelino, Mesquita, & Afonso, 2008; Rodríguez-Ruiz et al., 2011). Volleyball includes several types of jump techniques (jump for jump float serve, spike and spin serve, setting and block) and new studies can focus on identifying optimum physical prepara-

tion for performing these kinds of jumps during competition.

Very few studies of volleyball and beach volleyball have defined or accurately categorized types of ball touches. In a beach volleyball study (Palao, Valadés, Manzanares, & Ortega 2014), the authors did not specifically define which touches corresponded to hits and contacts. Almujahed, Ongor, Tigmo, and Sagoo (2013) equated all touches of the ball as follows: serve and attack with hits, and reception, set, block and dig-defense with contacts. Others associated them individually: serve with hit (Lidor & Mayan, 2005; López, 2013); reception, set, block and dig-defense with contact (Afonso et al., 2012; Palao et al., 2014); and attack with hit (Palao et al., 2014). In this study, every touch of the ball during the point is divided into one of two basic groups: hits and contacts. Serve and attack belong to the group of hits and all other touches (reception, pass by setter, block and defense (dig) belong to the group of contacts.

Vilamitjana et al. (2008) assessed jump profile in elite male volleyball players with particular reference to playing position. Part of the study by Sheppard, Gabbett, and Stanganelli (2009) addressed the jumping ability of various playing positions in elite male volleyball players. Using different terminology from our study, Marcelino and Mesquita (2008) examined the number of contacts and performance in volleyball by set result.

The purpose of this study was to determine the influence of the two new rules tested at the first U23 Men's Volleyball World Championship (21-point set excluding the fifth set, and 15 seconds between rallies–10 seconds from the finished point until the referee's whistle for serve and five seconds for per-

forming the serve) on the number and types of jumps related to In-game role and Level of set win, and number of contacts and hits related to each In-game role and Set outcome.

Methods

A total of 36 of the 38 matches played at the U23 Men's World Championships in Uberlandia (Brazil) were analyzed. At this unique tournament in the history of volleyball, changes to the Rally Point System were tested for the first time. The U23 World Championships took place in October 2013, with 12 national teams participating. The tournament followed the FIVB competition system with the addition of two new rules tested: set to 21 points per set (excluding the fifth set, to 15 points) with a minimum two-point difference at the end of sets, and 15 seconds before the referee's whistle for serve (FIVB, 2013b).

Official authorization from FIVB was granted for this study to use all the videos of matches and data from the Volleyball Information System (VIS) and the FIVB website. The competition had two rounds: a group phase (Pool A and B), and semifinals and finals. In the group phase, 30 matches were played, and in the semifinals and finals, eight were played. All 12 teams, divided into two groups of six, played according to the round-robin system to determine the ranking and were classified from 1st to 6th. The team ranked 3rd in Pool A played the team ranked 4th in Pool B. The team ranked 3rd in Pool B played the team ranked 4th in Pool A. The losers of the semi-final matches played for 7th and 8th final places, and the winners of the semi-final matches played for 5th and 6th places. The team ranked 1st in Pool A played the team ranked 2nd in Pool B. The team ranked 1st in Pool B played the team ranked 2nd in Pool A. The losers of the semi-final matches played for 3rd and 4th place and the winners of the semi-final matches played for 1st and 2nd place (FIVB, 2013a).

The study was conducted in two parts.

Investigation 1: Number and types of jumps

The first investigation analyzed jumps in relation to the new rules tested. Data were collected by watching 36 matches using a previously prepared data form containing all variables. In total, 25,930 jumps during 36 matches of the inaugural U23 Men's World Championships in Uberlandia were analyzed.

Investigation 2: Number and types of contacts and hits

The second investigation analyzed the contacts and hits in relation to the new rules tested. Data were collected from 36 matches from the VIS posted on the FIVB website and recorded on an analysis scheme form, as recommended by Tsimpiris, Tsamourtzis, Sfingos, Zaggelidis, and Zaggelidis (2006) for defining and examining variables.

Participants

The analysis comprised 15,706 contacts and 10,224 hits during 36 matches played by 144 male players under 23 years of age at the first U23 Men's World Championships, in Uberlandia. The average age of players was 21.1 ± 1.4 years. This age group competes successfully in the highest men's volleyball leagues internationally and therefore the games are of a similar level to elite men's volleyball. FIVB officially authorized this study and the use of all match videos and data from the VIS statistical recording program and the FIVB website. The study was performed in accordance with the Helsinki Declaration of 1975 and approved by the Ethics Committee of the University of Las Palmas de Gran Canaria. For both investigations, players were classified as setters, outside hitters, middle blockers, opposites and liberos.

Measuring equipment

The data were collected from 36 pre-recorded videos. All matches were recorded using a PANASONIC HC-V720 HD digital camcorder in AVCHD format. To obtain the best angle to capture everything happening on and beside the court, the camera was always located behind the court at a height of 5 meters above the floor (Claver, Jiménez, Gil, Moreno, & Moreno, 2013). FIVB's VIS software quantifies individual skills and is accepted as a valid instrument in volleyball research, as it has been used in various studies (Marcelino & Mesquita, 2008; Marcelino et al., 2008; Marcelino et al., 2009).

Value categories (measures)

Vilamitjana et al. (2008) used the following variables: 1) frequency of jumps per player, grouped by four field positions, 2) percentage of jumps in volleyball skills (spiking, spiking approach, jump service, blocking and setting) by player, 3) work time during the set: total set time minus resting. Total number of jumps and total work time were calculated per player. Work-rate profile (WRP) during competition was determined by the ratio between total number of jumps and work time.

Several authors (Marcelino & Mesquita, 2008; Marcelino, Mesquita, Sampaio, & Moraes, 2010) used similar variables for contacts: number of spike points, spike errors, spike continuity, block points, block errors, block continuity, serve points, serve errors, serve continuity, dig excellent, dig errors, dig continuity, set excellent, set errors, set continuity, reception excellent, reception errors and reception continuity, set win and set loss.

In Investigation 1, the variables analyzed were the jumps performed during actions A-E below, related to in-game role (setter, outside hitter, middle blocker, opposite, and libero), and Level of set win (Walkover, Balanced, and Tough set), where Walkover sets were the group of sets finished by 21:15 (and less than 15 points), Balanced sets were finished with 21:16, 21:17, and 21:18, and Tough sets finished with a two-point difference (21:19, 22:20... or 15:13, 16:14... in the fifth set).

- A. Jump for Jump Float Serve (JFS).
- B. Jump for Jump Spin Serve (JSS).
- C. Jump for attack.
- D. Jump for setting.
- E. Jump during block.

In Investigation 2, the following variables were analyzed by in-game role (setter, outside hitter, middle blocker, opposite and libero) and Set outcome (set Winner and set Loser):

- A. Hit
 - a. Serve.
 - b. Attack.
- B. Contacts
 - a. Reception.
 - b. Setting.
 - c. Block.
 - d. Defense.

Procedures (observing data protocol)

The FIVB technicians specially trained for VIS, who were approved, supervised and appointed by the FIVB Technical Commission, collected data about contacts and hits. VIS software is the method most commonly used by coaches and observers to assess individual and collective performance of volleyball players in each phase of the game. It has become the most frequently used software for FIVB data collection because of its efficiency, simplicity and accuracy (FIVB, 2000).

To ensure consistency in the criteria and quality in coding the data, the observer was trained beforehand. Training comprised a briefing on the definition of the variables and a data re-

ording period of two weeks until he obtained a Cohen’s Kappa value higher than 0.90. The observer had at least three years’ experience in data logging in earlier volleyball research and extensive experience as a scout and coach in this sport.

Reliability

To ensure reliability, 12% of the rallies were re-analyzed, exceeding the reference value of 10% (Tabachnick & Fidell, 2013). Cohen’s Kappa ranged from 0.84 to 0.91 for inter-observer reliability and 0.82 to 0.92 for intra-observer reliability. All values met the criterion of 0.75 suggested in the literature (Fleiss, Levin, & Paik, 2003).

Statistical analysis

All numerical data are shown by frequency, separated into each volleyball element analyzed. Pearson’s Chi-Square test was used to test significant differences between frequencies registered in individual subsamples. Significance between means established for specific elements in specific subsamples was tested using the T-test and One-Way ANOVA. Statistical analysis was conducted using IBM SPSS Statistics V19 software. Statistical inference was performed at the level of significance of 0.05 ($p < 0.05$).

Results

Investigation 1

Match and set analysis of absolute and relative frequency of jump types showed that the highest number of jumps made by all teams was during the elements attack ($M_{match}=103\pm27$ jumps; $M_{set}=30\pm7$ jumps) and block ($M_{match}=102\pm26$ jumps; $M_{set}=30\pm7$ jumps). Half as many jumps were performed during setting ($M_{match}=51\pm15$ jumps; $M_{set}=15\pm5$ jumps) and fewest jumps were registered during JFS ($M_{match}=38\pm15$ jumps; $M_{set}=11\pm4$ jumps) and JSS ($M_{match}=22\pm8$ jumps; $M_{set}=7\pm3$ jumps). In percentages, 33% of jumps were performed during attack, 32% during block, 16% during setting, 12% during JFS and only 7% during JSS. No significant differences were found for the distribution of jump types by Level of set win.

Analysis of number of jumps by in-game role showed that Middle blocker performed the most jumps during the match, followed by Outside hitter, Setter and Opposite in-game roles (Table 1). Although Libero registered a low number of jumps, it was interesting to analyze the type of jumps this in-game role performed.

Table 1. Average Distribution of Jumps by In-game Role

Jump	Setter (%)	Outside hitter (%)	Middle blocker (%)	Opposite (%)	Libero (%)	Total (%)
JFS	26.2	30.2	36.5	7.1	/	100
JSS	12.7	44.1	11.9	31.3	0.0	100
Attack	1.6	28.5	46.3	23.7	0.0	100
Setting	95.6	1.0	1.6	1.1	0.6	100
Block	14.4	26.9	43.7	15.0	/	100
Total	24.6	24.9	34.7	15.8	0.1	100

Chi-Square = 13794.922* $p=0.000$

Note. Asterisk (*) indicates statistically significant difference.

Analysis of individual positions in the game showed that Setter, as expected, performed the highest number of jumps during setting ($M=98\pm88$ jumps), block ($M=29\pm26$ jumps) and

Jump Float Serve ($M=20\pm17$ jumps), and the lowest number of jumps in Jump Spin Serve ($M=6\pm3$ jumps) and attack ($M=3\pm2$ jumps).

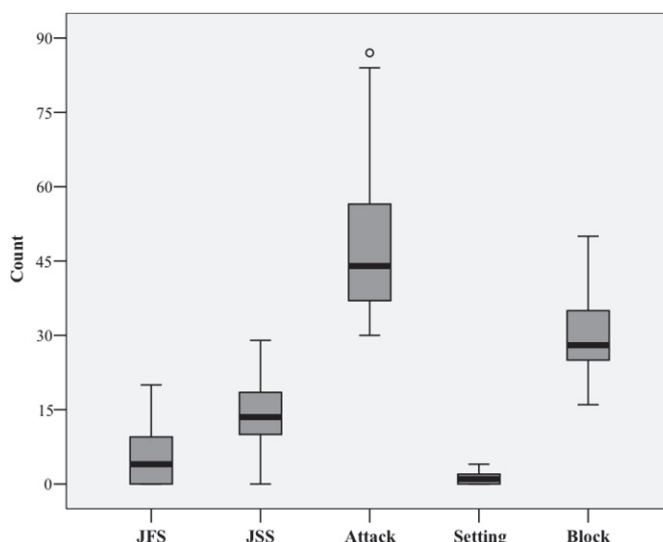


Figure 1. Average descriptive indicators for jumps by opposite in-game role per match. Circle (°) above the bar represents an individual extreme value that exceeded 3 standard deviations and is excluded from the analysis as parasitic data

Outside hitter performed almost the same number of jumps in attack ($M=59\pm54$ jumps) and block ($M=55\pm49$ jumps). Mean values for this in-game role were 23±19 jumps during serve by Jump Float and 20±17 jumps during Jump Spin Serve. As expected, the

minimum number of jumps was in setting ($M=1\pm1$ jump).

Middle blocker in-game role, the leading jump position, had a mean value of 96±87 jumps in attack per match and a slightly lower value in block (89±80 jumps). During Jump Float Serve

the average was 28 ± 24 jumps, with more than five times fewer during Jump Spin Serve ($M=5 \pm 4$ jumps). In setting, as expected, this in-game role performed minimum jumps ($M=2 \pm 1$ jumps).

Opposite in-game role had a mean value of 49 ± 45 jumps per match in attack, with a maximum value of 87 jumps and a minimum of 30 (Figure 1). In block, this in-game role performed an average of 30 ± 9 jumps, followed by jumps in Jump Spin Serve ($M=14 \pm 12$ jumps) and Jump Float Serve ($M=6 \pm 4$ jumps). Opposite in-game role performed minimum jumps during setting ($M=1 \pm 1$ jump).

Jumps by Libero were registered in only 14 of the 36 matches analyzed. From a total of 20 jumps Libero performed during the whole tournament, 19 were during setting. In eight matches Libero performed one jump per match during setting, in three matches two jumps per match and in one match five

jumps. Analysis of the 13 matches in which Libero jumped during setting showed a low average value of 1.62 ± 1.12 jumps (minimum 1, maximum 5). Calculating the values for 36 matches, the values registered for Libero were $M=0.58 \pm 1.025$ jumps, $Min=0$ jumps, $Max=5$ jumps.

Investigation 2

T-test analysis of number and types of Hits showed a significant difference between set Winner and set Loser teams only for serves by Setter ($p < 0.001$) and Middle blocker ($p < 0.05$), while no statistical differences were found for other Hit performers (Table 2). Setter and Middle blocker from set Winners hit the ball significantly more (by 4-5 hits) during serve than the same in-game roles from set Losers.

Table 2. Statistical Descriptive for Hit Elements (per Match)

Hit	Team	N	Mean	Std. Deviation	Std. Error Mean	T-test	p
Serve.S	Winner	36	15.61	5.738	0.956	4.157*	0.000
	Loser	36	10.75	4.038	0.673		
Serve.OH	Winner	36	23.08	5.949	0.992	1.433	0.156
	Loser	36	20.61	8.473	1.412		
Serve.OP	Winner	36	9.97	3.707	0.618	1.289	0.202
	Loser	35	8.80	3.954	0.668		
Serve.MB	Winner	36	21.81	5.651	0.942	2.844*	0.006
	Loser	36	17.75	6.425	1.071		
Attack.S	Winner	33	2.48	1.326	0.231	-0.969	0.336
	Loser	32	2.84	1.648	0.291		
Attack.OH	Winner	36	34.03	11.000	1.833	-1.462	0.148
	Loser	36	38.36	13.970	2.328		
Attack.OP	Winner	36	24.86	9.372	1.562	-0.453	0.652
	Loser	36	26.00	11.835	1.972		
Attack.MB	Winner	36	14.03	5.945	0.991	0.291	0.772
	Loser	35	13.63	5.610	0.948		
Attack.L	Winner	1	1.00	/	/	/	/
	Loser	2	8.50	2.121	1.500		
Total hits	Winner	36	145.69	33.126	5.521	0.883	0.380
	Loser	36	138.28	37.996	6.333		

Note. ^S=Setter, ^{OH}=Outside Hitter, ^{MB}=Middle blocker, ^{OP}=Opposite, ^L=Libero. Asterisk (*) indicates statistically significant difference.

In the Hits group, Outside hitter performed 22 ± 7 hits during serve, followed by Middle blocker ($M=20 \pm 6$ hits), Setter ($M=13 \pm 6$ hits) and Opposite ($M=9 \pm 4$ hits) (Figure 2).

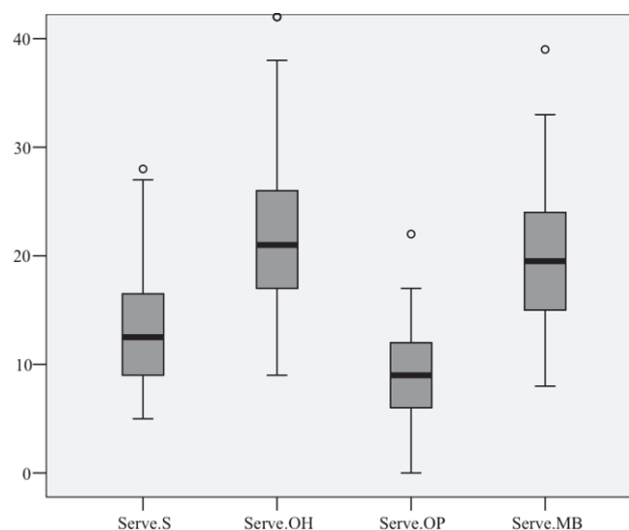


Figure 2. Descriptive for hits performed by servers (per match). Circles (°) above the bars represent individual extreme values that exceeded 3 standard deviations and are excluded from the analysis as parasitic data. ^S = Setter, ^{OH} = Outside hitter, ^{MB} = Middle blocker, ^{OP} = Opposite

In attack, Outside hitter executed the most hits ($M=25\pm 11$ hits), followed by Opposite ($M=25\pm 11$ hits), Middle blocker ($M=14\pm 6$ hits) and Setter ($M=2\pm 2$ hits).

T-test comparison between set Winner and set Loser data for contacts showed significant differences in block by Opposite players ($p<0.05$) and Middle blocker players ($p<0.05$), and in reception by Libero ($p<0.05$). The in-game role that touched

the ball most per match was Setter from set Loser teams in setting ($M=66\pm 18$ contacts), followed by the same position from set Winner teams in setting ($M=60\pm 22$ contacts). The second in-game role by number of contacts was Outside hitter from set Loser teams during reception ($M=41\pm 13$ contacts), followed by the same position from set Winners during reception ($M=36\pm 13$ contacts) (Table 3).

Table 3. Statistical Descriptive for Contact Elements (per Match)

Contact	Team	N	Mean	Std. Deviation	Std. Error Mean	T-test	p
Block.S	Winner	36	5.33	3.295	0.549	0.837	0.405
	Loser	35	4.71	2.916	0.493		
Block.OH	Winner	36	10.36	3.322	0.554	0.884	0.380
	Loser	36	9.44	5.261	0.877		
Block.OP	Winner	36	6.89	3.740	0.623	2.111*	0.038
	Loser	35	5.17	3.073	0.519		
Block.MB	Winner	36	16.67	7.282	1.214	2.270*	0.026
	Loser	36	13.08	6.054	1.009		
Defense.S	Winner	36	8.39	3.705	0.618	-1.294	0.200
	Loser	36	9.50	3.582	0.597		
Defense.L	Winner	36	13.53	5.406	0.901	-0.195	0.846
	Loser	36	13.78	5.452	0.909		
Defense.OH	Winner	36	15.83	6.153	1.025	-1.326	0.189
	Loser	36	18.31	9.344	1.557		
Defense.OP	Winner	36	6.58	3.324	0.554	-0.795	0.429
	Loser	35	7.26	3.807	0.643		
Defense.MB	Winner	36	4.89	2.638	0.440	-1.360	0.178
	Winner	35	5.91	3.649	0.617		
Setting.S	Winner	36	60.36	22.049	3.675	-1.120	0.267
	Loser	36	65.72	18.415	3.069		
Setting.L	Winner	33	4.09	2.185	0.380	-1.291	0.201
	Loser	35	4.80	2.336	0.395		
Setting.OH	Winner	33	4.03	2.114	0.368	-1.714	0.091
	Loser	35	4.97	2.395	0.405		
Setting.OP	Winner	21	2.33	1.017	0.222	0.541	0.591
	Loser	27	2.19	.879	0.169		
Setting.MB	Winner	29	3.00	1.626	0.302	0.799	0.428
	Loser	33	2.67	1.652	0.288		
Reception.L	Winner	36	13.06	6.568	1.095	-2.056*	0.044
	Loser	36	16.64	8.139	1.356		
Reception.OH	Winner	36	35.61	13.122	2.187	-1.692	0.095
	Loser	36	40.81	12.928	2.155		
Reception.MB	Winner	11	1.45	.934	0.282	-.994	0.329
	Loser	19	2.00	1.667	0.382		
Reception.S	Winner	8	1.00	0.000	0.000	/	/
	Loser	13	1.00	0.000	0.000	/	/
Reception.OP	Winner	0	/	/	/	/	/
	Loser	9	7.11	6.353	2.118	/	/
Total	Winner	36	209.42	64.748	10.791	-1.194	0.236
Contacts	Loser	36	226.47	56.129	9.355		

Note. ^S=Setter, ^{OH}=Outside hitter, ^{MB}=Middle blocker, ^{OP}=Opposite, ^L=Libero. Asterisk (*) indicates a statistically significant difference.

For contacts with the ball during block per match, Middle blockers performed the highest number ($M=15\pm 7$ contacts), followed by Outside hitter ($M=10\pm 4$ contacts), whereas Opposite ($M=6\pm 4$ contacts), and Setter ($M=5\pm 3$ contacts) touched the ball considerably less (Figure 3).

For contacts with the ball in defense, Outside hitter had a mean value of 17 ± 8 contacts per match, followed by Libero ($M=14\pm 5$ contacts), with considerably lower values achieved

by Setter ($M=9\pm 4$ contacts), Opposite ($M=7\pm 4$ contacts) and Middle blocker ($M=5\pm 3$ contacts).

For contacts with the ball during setting, Setter is the absolute leader for number of touches, with a mean value of 63 ± 20 contacts per match, followed by Outside hitter ($M=4\pm 3$ contacts), Libero ($M=4\pm 3$ contacts), Middle blocker ($M=2\pm 2$ contacts) and Opposite ($M=2\pm 1$ contacts).

Outside hitter led in the number of contacts during recep-

tion, with a mean value of 38 ± 13 contacts, followed by Libero with a mean of 15 ± 8 contacts, and minimum values were ob-

tained by Opposite ($M=1 \pm 3$ contacts), Middle blocker ($M=1 \pm 1$ contact) and Setter.

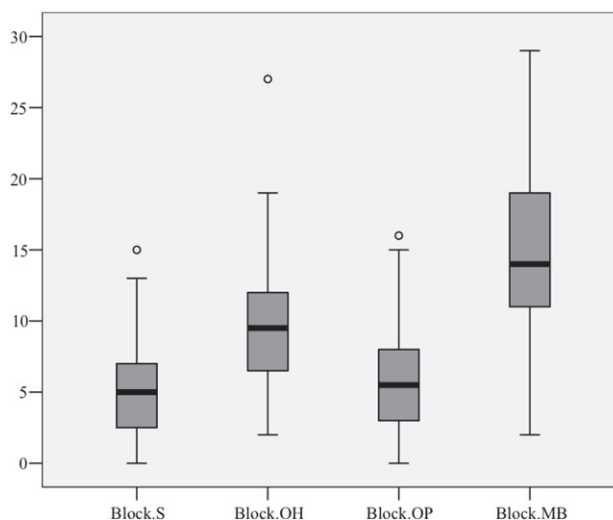


Figure 3. Descriptive for contacts made by blockers (per match). Circles (°) above the bars represent individual extreme values that exceeded 3 standard deviations and are excluded from the analysis as parasitic data. ^S = Setter, ^{OH} = Outside hitter, ^{MB} = Middle blocker, ^{OP} = Opposite, ^L = Libero

Discussion

Few studies have addressed the number and type of jumps by in-game role and Level of set win or hits and contacts by in-game role and Set outcome in volleyball. In beach volleyball, Palao et al. (2014) found no statistical difference between in-game roles for average jumps, contacts and hits per play. Marcelino et al. (2010) reported significant differences for contacts. Serve point, serve continuity and spike point are the performance indicators most correlated with win in volleyball (Marcelino & Mesquita, 2008), which is closely related to the parts of this study concerning Hits.

Jumps

Information about the number and type of jumps gives coaches appropriate insight into the physical exertion and technical requirements by each in-game role. Sheppard et al. (2007) and Sheppard et al. (2009) identified Middle blocker as the most frequent performer of jumps during block in comparison to Setters and Outsides hitters, while Middle blockers performed more jumps during attack than Outside hitter and Setter, concurring with our study. Vilamitjana et al. (2008) reported that the most frequent performer of jumps is Middle blocker, followed by Outside hitter, Setter and Opposite, also concurring with our study. The same authors found that most jumps are performed during block (37.9%) and attack (21.7%), in agreement with our study, although the values in our study were similar (about 33% each, of total jumps). In the same study, 17.6% of jumps were performed during Jump Serve and 14.5% during setting, compared to 7% during JSS, 12% during JFS and 16% during setting in our study.

To be able to compare our results to the study by Vilamitjana et al. (2008), a simple conversion process into percentages was necessary. Vilamitjana et al. (2008) identified Setter with about 67.5% of jumps during setting, recording a similar percentage (15%) of both jumps in block and serve, whereas in our study Setter performed 62.6% during setting, 18.8% during block and 16.5% in serve, including both JFS and JSS. The same authors found that Outside hitter performed most jumps

during block (45%), followed by jumps during spiking (about 32%) and serve (about 21%), whereas in our study the same in-game role performed most jumps during attack (37.4%), followed by block (34.8%) and jump serve using both JFS and JSS (27.2%). According to Vilamitjana et al. (2008), Middle blocker performed about 47% of jumps during block, about 17% during serving and 14% during spiking, whereas in our study the same position jumped less in block (30.5%), considerably more in attack (43.6%) and slightly less in Jump Serve, including JFS and JSS (15.2%). Opposite is the absolute leader in jumps during attack, in which this in-game role performed about 46% of total jumps in the study by Vilamitjana et al. (2008) and around 17% during Jump Serves, whereas in our study the value for jumps during attack was slightly higher (49.0%), 19.4% during both JFS and JSS, and 30.5% during block.

Given the lack of references to jumps by Libero in the literature, this study will be among the first to draw attention to the new tendency of Libero to jump during setting. In our study, 95% of jumps performed by Libero were during setting. Libero can also attack according to official volleyball rules (FIVB, 2012), but in official matches it has been seen that coaches often become frustrated because of a limited understanding of the rules of the game.

Hits and Contacts

For hits, the significant difference for setter and middle blocker by set outcome and in-game role agree with the findings of Marcelino and Mesquita (2010), who found significant differences in attack and serve by set outcome. According to Marcelino and Mesquita (2006), the average attack attempt (corresponding to the term “attack hit” in this study) per match is 97.09 ± 20.25 and the average serve attempt (corresponding to “serve hits”) is 88.15 ± 16.17 .

Marcelino et al. (2010) found significant differences in reception, block, defense and between set Winners and Losers, whereas in our study significant differences were found for Set outcome for three in-game roles: Libero for reception and Opposite and Middle blocker for block. In the study by Marcelino

and Mesquita (2006), the term “average block attempts” (48.30 ± 14.93) corresponds to contacts in block, “dig attempts” ($M = 55.63 \pm 16.48$ attempts) corresponds to contacts in defense and “reception attempts” (70.82 ± 14.59) corresponds to contacts in reception. Analysis of setting shows that Setter must be technically and physically well prepared to perform about 63 ± 20 passes, whereas Outside hitter and Libero perform only 4 ± 3 passes per match. Middle blocker and Opposite appear to set extremely rarely.

Conclusion

In high-level volleyball each in-game role is characterized by a specific physical and technical profile. This investigation revealed major differences in jumps, hits and contacts between in-game roles, identifying Middle blocker as the most frequent jumping position, followed by Outside hitter and Setter. Middle blocker was found to be the most decisive in-game role in the serve and in contacts during block. Libero showed a new tendency of being Setter with a jump after the initial Setter defense action. This study provides researchers with full details about jumps, contacts and hits in volleyball under the new rules tested. It can be a good base for future research, such as conducting a comparison with the present rules (25-point set, no

time limit between rallies) in all men’s categories. If FIVB applies these rules, similar research could be conducted among all men’s and women’s categories. The study does not examine the relation between jumps and Set outcome, which could provide interesting information such as whether players from set Winners or Losers jump more frequently and which types of jumps they use. This complex study of each jump, contact and hit during every volleyball set provides an in-depth definition of the game.

Acknowledgments

The authors wish to thank Dr. Miljan Grbović, former physical trainer of the Serbian Volleyball National Team, for his wholehearted support and help in this study, and the specially trained FIVB technicians, who are approved, supervised and appointed by the FIVB Technical Commission, for recording all the World Championship matches: Denis Popov (Russia), Manuel Abraham Calderón (Mexico), Saša Joksimović (Serbia) and Genaro López (Argentina). This study would not have been possible without the kind permission of the Fédération Internationale de Volleyball (FIVB) to use all the videos and information from the U23 Men’s Volleyball World Championships.

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