

Analysis of serve characteristics under rules tested at Volleyball Men's Under 23 World Championship Análisis de las características del saque en función de las reglas probadas en el Campeonato del Mundo de Voleibol Masculino sub-23

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Abstract. The aim of this study was to analyse the characteristics of the volleyball serve with the new rules tested at the inaugural Volleyball Men's Under 23 World Championship (set to 21 points, excluding the fifth set; 15 seconds between points). In a sample of 36 matches played in 123 sets, 4588 serves were studied. The variables used were serve type, serve quality, serve zone, placement zone, in-game role, score trend and set outcome. Pearson's Chi-Square test was used for data analysis. Significant differences were observed in the following variable relations: serve type by in-game role ($p = .000$), serve type by score trend ($p = .000$), serve quality by serve zone ($p = .039$), serve quality by in-game role ($p = .000$), serve quality by set outcome ($p = .000$), serve zone by in-game role ($p = .000$), serve zone by set outcome ($p = .000$), placement zone by serve quality ($p = .000$) and placement zone by serve zone ($p = .004$). If these changes become part of the official volleyball rules, this study will be a useful guide for building team tactics and strategy. It also provides insight for FIVB about the effect of the tested rules for further developments in the game.

Key words. in-game role, serve zone, receiving zone, serve quality, set phase, serve type.

Resumen. El objetivo de este estudio fue analizar las características del saque en voleibol con las nuevas reglas probadas en el primer Campeonato del Mundo Sub 23 Masculino (set a 21 puntos, excluyendo el quinto set; 15 segundos entre puntos). En una muestra de 36 partidos disputados en 123 sets, fueron estudiados 4588 saques. Las variables utilizadas fueron: tipo de saque, calidad del servicio, zona de saque, zona a la que se saca, rol del jugador que saca, la tendencia del marcador en el momento del saque y el resultado final del set. Para el análisis de los datos se utilizó la prueba Chi-Cuadrado de Pearson. Se observaron diferencias significativas en la relación de las siguientes variables: tipo de saque y rol del jugador que saca ($p = .000$), tipo de saque y tendencia del marcador ($p = .000$), calidad del servicio y zona de saque ($p = .039$), calidad del servicio y rol del jugador que saca ($p = .000$), calidad del servicio y resultado del set ($p = .000$), zona de saque y rol del jugador que saca ($p = .000$), zona de saque y resultado del set ($p = .000$), zona a la que se saca y calidad del saque ($p = .000$) y zona a la que se saca y zona de saque ($p = .004$). Si estos cambios forman parte de las reglas oficiales de voleibol, este estudio será una guía útil para construir la táctica y la estrategia del equipo. También proporciona información para la FIVB sobre el efecto de las reglas probadas para futuros desarrollos del juego.

Palabras clave: rol del jugador, zona de saque, zona de recepción, calidad del servicio, fase del set, tipo de saque.

Introduction

Volleyball is a team sport that has been played since 1895. Because of the many changes and developments introduced, it has become a dynamic, popular sport throughout the world (Claver, Jiménez, Gil, Moreno, & Moreno, 2013; Huang & Hu, 2007; Tillman, Hass, Brunt, & Bennet, 2004). In 2013, Fédération Internationale de Volleyball (FIVB) organised the inaugural Men's U23 World Championship, where the main goal was to test new rules intended to modernise volleyball and make it more appealing for fans both at matches and watching television (Fédération Internationale de Volleyball [FIVB], 2013b).

Many of the changes in the history of volleyball have affected the first element in the game: the serve (García-Tormo, Redondo, Valladares, & Morante, 2006; Molina, Santos, Barriopedro, & Delgado, 2004). In 1897, William G Morgan introduced the serve as the first written rule (Giddens & Giddens, 2005; Kenny & Gregory, 2006; López, 2013; Ureña, Gallardo, Delgado, Hernández, & Calvo, 2000). In the earliest rules, the following applied to the serve: 1) the serving player had two attempts, in case the first serve failed; 2) the server had to have one foot on the back line and use his hand to hit the ball, which had to go over the net without touching; 3) a partner could help the ball over the net using one touch; 4) if the serve was correct there was no second serve; and 5) every «unreceived» serve was a point for the team who served, but if the opponent team scored, they earned the chance to serve. In 1920 the rules were modified and the server was not permitted to step on the back line of the court during the serve. In 1947 the server had to serve from the right side behind the court (back line), still with one foot on the ground (Ureña et al., 2000). In 1949 the server could run and jump before hitting the ball, and in 1951 the server could land inside the court after jumping and hitting the ball. The serving zone was expanded to an unlimited area behind the line, but in 1953 it was limited by two lines of 20 cm behind the back line of the court (Ureña et al., 2000). More than 40 years later, further new rules for serving were

added: in 1994 the serve zone was extended to 9 m to provide more options in serving (Ureña et al., 2000); from 1998 the server had only one attempt to serve, to reduce the duration of the match; and from 1999 the server had 8 seconds to serve. In 2000 the ball was allowed to touch the top of the net and pass over it without interrupting the continuity of the game (FIVB, 2015).

The serve is the action of hitting the ball with the arm and directing it over the net into the opponent's court by the server placed in the serve zone (Conejero, Claver, Fernández-Echeverría, Gil-Arias, & Moreno, 2017), who has 8 seconds from the first referee's signal for serve (FIVB, 2012). The volleyball serve is a technical skill (Parisi, & Raiola, 2014a) and a complex individual skill that can be adapted depending on the match situation, the player's capabilities and tactical needs (Moras et al., 2008). In volleyball, each team has four options (Häyriinen, Hoivala, & Blomqvist, 2004) for scoring points: by serving, blocking, attacking and from opponent error. As the first offensive action (Raiola, Altavilla, De Luca, & Di Tore, 2016) through which a point can be scored, the volleyball serve is an essential element of today's elite volleyball (Asterios, Kostantinos, Athanasios, & Dimitrios, 2009; Dávila-Romero, García-Hermoso, & Saavedra, 2012; Drikos, Kountouris, Laios, & Laios, 2009; Huang & Hu, 2007; Masumura, Marquez, Koyama, & Michiyoshi, 2007; Moras et al., 2008). The primary goal of the serve is to score a direct point (ace) or to prevent the opponent making a good attack (Claver et al., 2013; MacKenzie, Kortegaard, LeVangie, & Barro, 2012; Raiola et al., 2016). The serve action directly depends on one player (Marcelino, Mesquita, & Afonso, 2008; Raiola et al., 2016) and the player's technical, physical and psychological preparation.

Serve and reception are related elements that determine the continuation or the end of the point. When the serve is better than the reception, the serving team can score a direct point or disrupt the opponent's attack (Rentero, João, & Moreno, 2015). The attack has changed over time because reception has been constantly forced to adapt to changes in the serve (Ureña et al., 2001). In the last 15 years, *Jump Spin Serve* (JSS) and *Jump Float Serve* (JFS) have become the predominant serve types in men's volleyball (Agelionidis, 2004;

Häyriinen, Lahtinen, Mikkola, Honkanen, Paananen, & Blomqvist, 2007; Moras et al., 2008; Tsivika & Papadopoulou, 2008). Because of the importance of the serve and its relation to the final outcome, it is important to train and develop serve efficacy (João, Silva, Lacerda, & Vaz, 2012).

Many researchers have studied the serve action in relation to the following aspects: serve type, serve zone, reception zone, effectiveness, in-game role of the receiver, serve direction and timing (Gil-Arias, Claver, Fernández-Echeverría, Moreno, & Moreno, 2016); serve type and serve direction in men's volleyball (Moreno, García de Alcaráz, Moreno, Molina, & Santos, 2007); serve technique, zone from where the player serves, serve direction and serve efficiency (Callejón-Lirola, 2006); serve type, in-game role, quality of serve, serve outcome, placement zone (Ciuffarella, Russo, Masedu, Valenti, Izzo, & De Angelis, 2013); effectiveness of the serve in a high-level volleyball tournament (Moras et al., 2008); and positive serve and negative serve (Dávila-Romero et al., 2012).

At the inaugural Volleyball Men's Under 23 (U23) World Championship, in Brazil (Uberlandia), two new rules were tested (FIVB, 2013a). The first was directly connected to the serve and the second was indirectly connected to the serve. The 15 second rule for serve means that the player hears the referee's signal to serve within 10 seconds of the point finishing and has 5 seconds to perform the serve. With the second rule, the set is won by the first team to win 21 points with a minimum difference of 2 points, except the final fifth set, which is unchanged (FIVB, 2013b). The aim of this study was to analyse the characteristics of the volleyball serve (Serve type, Serve zone, Placement zone, In game-role, Score trend and Set outcome) during new rules tested at the inaugural Volleyball Men's Under 23 World Championship (set to 21 points, excluding the fifth set; 15 seconds between points).

Methods

Participants

The sample comprised 36 matches played in 123 sets by the 144 players from the 12 national teams participating at the Men's U23 World Championships in Uberlandia (Brazil). An analysis was made of 4588 serves. The national teams participating in the study were from Argentina (6 matches analysed), Australia (5 matches), Brazil (7 matches), Bulgaria (7 matches), Dominican Republic (5 matches), Egypt (5 matches), Iran (7 matches), Mexico (4 matches), Russia (7 matches), Serbia (7 matches), Tunisia (6 matches) and Venezuela (6 matches).

Variables

Several studies have used similar variables to those in this study. In the study by Fernández-Echeverría, Gil, Moreno, Claver, and Moreno (2015), the independent variables were serve zone, serve type, striking technique, in-game role of the server, reception zone, receiver player and serve direction, and the dependent variable was serve efficacy. Callejón-Lirola (2006) used the categories and variables of: 1) Serving technique: jump spin serve, jump float serve, overhead float serve; 2) Areas from where the serve is made: behind zone 1, behind zone 6, behind zone 5; 3) Qualitative measure of serve efficiency: six different values; and 4) Zone of impact of the serve: nine zones.

In this study, the serve variables were divided into 7 categories:

I. Type of serve:

Overhead Float Serve (OFS).

Jump Float Serve (JFS).

Jump Spin Serve (JSS).

II. Quality of serve, divided into 5 levels (López-Martínez & Palao, 2009):

0 = error.

1 = maximum opponent attack options (action was easily passed and allowed the opponent to attack).

2 = limited attack options for the opponent (action was passed and

opponent attacked with some attack options - «second tempo» actions).

3 = no opponent attack options (action was passed but opponent could not attack; they simply passed the ball - free ball).

4 = Point (ace).

III. Serve zone (Zone from where the player serves) (Callejón-Lirola, 2006):

Serve execution behind zone 1 (BZ1).

Serve execution behind zone 6 (BZ6).

Serve execution behind zone 5 (BZ5).

IV. Placement zone on the opponent's court (divided into 9 equal fields) (Figure 1).

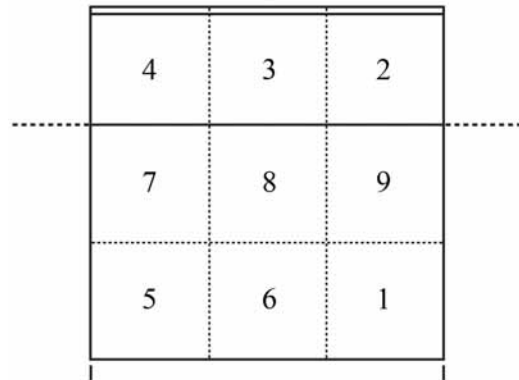


Figure 1. Serve placement zones.

V. In-game role: 1 = setter; 2 = outside hitter; 3 = middle blocker; 4 = opposite.

VI. Score trend (*Early, Middle, and Final phase*). *Early* phase is from the start of the set to the 8th point (6th point in the fifth set), *Middle* phase from 9th to 16th point (7th to 12th point in the fifth set), and *Final* phase from the 17th point to the end of the set (from 13th point to the end of the set in the fifth set).

VII. Set outcome: *Set Winner* and *Set Loser* (González-Silva, Moreno, Fernández-Echeverría, Conejero, & Moreno, 2016).

The Volleyball Information System (VIS), created by the Technical Commission of the FIVB (FIVB, 2000), was used to collect data from the matches. FIVB's Volleyball Information System is used to calculate points scored for individual skills of volleyball players (FIVB, n.d.). This software is accepted as a valid tool in volleyball research and has been used in many studies (João, Leite, Mesquita, & Sampaio, 2010; Marcelino et al., 2008; Marcelino, Mesquita, Sampaio, & Anguera, 2009). Because of its efficiency, simplicity and accuracy, VIS is the software FIVB uses most frequently for collecting data. It is also the method most used by coaches and observers to assess individual and collective performance of players in each phase of the volleyball game (FIVB, 2000). VIS calculates the following serve values (FIVB, n.d.): Aces (the number of points directly scored by the serve); Faults (number of serve mistakes); Serve hits (number of serves played when the rally continues); and Total attempts (total number of serves). From all the data collected by the FIVB technicians specially trained for VIS, who are approved, supervised and appointed by the FIVB Technical Commission, only data referring to the competition phase was used.

Procedure

The 36 games were videotaped and evaluated. Video/match analysis in volleyball is of great importance for qualitative and quantitative performance assessment (Parisi, & Raiola, 2014b; Raiola et al., 2016; Raiola, Parisi, Giugno, & Di Tore, 2013). All games were filmed using the same PANASONIC HC-V720 HD digital camcorder in AVCHD

format. The camera was always located at the same position, behind the court at a height of 5 m above floor level (Claver et al., 2013) to obtain an optimal angle of view. Once the different categories and their corresponding variables had been established, they were studied and analysed from a quantitative and a qualitative point of view, following the principles established in the observational investigation (Callejón-Lirola, 2006).

FIVB officially authorised this study and the use of all match videos and data from the VIS statistical recording programme and the FIVB website. The study was performed in accordance with the Helsinki Declaration of 1975.

Reliability

The observer was trained to achieve consistency in the criteria and quality in coding the data. The training comprised a briefing on the definition of the variables and a data recording period of two weeks until he achieved a Cohen's Kappa value higher than .90. The observer had at least three years' experience in data logging during volleyball research and extensive experience as a volleyball scout and coach.

To ensure reliability of the calculation to avoid any learning effect, 12% of the serves were re-analysed after a six-week interval, exceeding the reference value of 10% (Tabachnick & Fidell, 2007). Two additional volleyball researchers and national coaches who had received 10 hours of training in data collection conducted secondary observation of the data. Cohen's Kappa ranged from .84 to .91 for inter-observer reliability and from .82 to .92 for intra-observer reliability. All values fulfilled the criterion of .75 suggested in the literature (Fleiss et al., 2003).

Statistical analysis

All numerical data are expressed in frequencies, specified for each volleyball element analysed. As all the statistical series had characteristics of nominal scale, Pearson's Chi-Square test was used as an appropriate data analysis procedure. The results were calculated using IBM SPSS v.19 software. The statistical inferences were performed at the significance level of .05 ($p < .05$).

Results

Serve type was analysed in relation to two criteria: in-game role and score trend.

SERVE TYPE by IN-GAME ROLE - Contingency analysis showed that different in-game roles used significantly different types of serve ($p = .000$). Comparison of relative frequencies showed that setters and middle blockers mainly used *Jump Float Serve* (77.3% and 71.6%), whereas opposite players performed *Jump Spin Serve* (72.0%) more often. Outside hitters also frequently used *Jump Float Serve* (54.9%), closely followed by *Jump Spin Serve* (44.7%) (Figure 2). Outside hitters performed the most serves (1531), followed by middle blocker (1411), setter (953) and opposite (692).

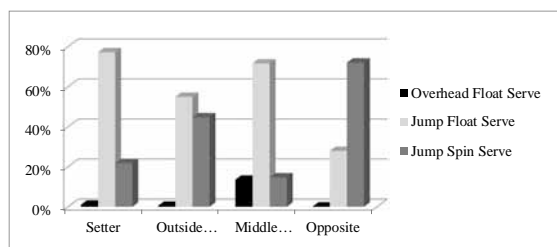


Figure 2. Serve type distribution by in-game role.

SERVE TYPE by SCORE TREND - The statistical analysis showed a significant difference between serve type and set phase ($p = .000$). Comparison of relative frequencies in all phases of the set showed that the most used serve type was *Jump Float Serve* (60.6%) and the least used was *Overhead Float Serve* (4.6%). *Jump Spin Serve* was performed for about a third of all serves (34.9%). In most sets, *Jump Float Serve* was used more in the *Final* phase (64.0%) than in the

Middle phase (62.9%) and the *Early* phase (55.8%). In contrast, the frequency of *Jump Spin Serve* (40.2%) in the *Early* phase was greater than in the *Final* phase (30.6%), while in the *Middle* phase the value was 32.6%. *Overhead Float Serve* was performed with the following values: *Early* phase 3.9%, *Middle* phase 4.5%, *Final* phase 5.4%.

Serve quality was analysed in relation to four criteria: serve zone, in-game role, score trend and set outcome.

SERVE QUALITY by SERVE ZONE - A significant difference ($p = .039$) was found between serve quality and serve zone. Relative frequency analysis showed that most serves related to serve quality were performed from BZ1 (54.6%), followed by BZ5 (26.3%) then BZ6 (19.1%). Almost 60.0% of aces were served from BZ1 (59.7%), compared to 22.0% from BZ5 and 18.3% from BZ6. Serve errors were predominant in serves from BZ1 (58.6%), compared to values of 21.3% from BZ5 and 20.1% from BZ6. Although serves resulting in *Free ball* had the lowest percentage (51.7%) among all serves from BZ1, the percentage from this zone was higher than from BZ5 (26.0%) and BZ6 (22.3%). Serves resulting in *Free ball* performed from BZ6 had the highest percentage among all serves from BZ6. From BZ5 the most frequent serves were those that resulted in first (27.8%) and third (26.9%) tempo attack and *Free ball* (26.0%).

SERVE QUALITY by IN-GAME ROLE - A significant difference ($p = .000$) was observed in the contingency analysis of serve quality by in-game role (Table 1). Analysis of descriptive characteristics and relative frequencies showed that most serves by all in-game roles gave the opponent the opportunity to organise all types of attack. *Opposite* is the in-game role with the lowest number of serves at the tournament ($n=692$), although these players accounted for the highest number of aces (7.4%) and the highest number of serve errors (22.5%), undoubtedly causing the greatest trouble for receivers. Serves by *Setter* in-game role ($n=953$) resulted in the highest number of opponent third-tempo attacks and free balls. From a total of 1412 serves, *Middle blocker* position had the highest relative frequency of serves that allowed a first-tempo attack (58.5%), followed by *Outside hitter* with 54.7% from 1531 serves.

Table 1
Serve quality distribution by in-game role

Serve quality	Setter		Outside hitter		Middle blocker		Opposite	
	Count	%	Count	%	Count	%	Count	%
Serve error	82	8.6	243	15.9	147	10.4	156	22.5
First tempo	484	50.8	838	54.7	826	58.5	277	40.0
Third tempo	244	25.6	270	17.6	288	20.4	138	19.9
Free ball	105	11.0	121	7.9	108	7.6	70	10.1
Ace	38	4.0	59	3.9	43	3.0	51	7.4
Total	953	100	1531	100	1412	100	692	100

Note. Chi-Square = 156.213*, ($p = .000$).

Table 2
Serve quality distribution by serve placement zone

Placement zone	Serve error		First tempo		Third tempo		Free ball		Ace	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
1	157	25.0	497	20.5	206	21.9	83	20.5	44	23.0
2	1	.2	4	.2	6	.6	1	.2	4	2.1
3	3	.5	3	.1	7	.7	8	2.0	7	3.7
4	2	.3	4	.2	2	.2	1	.2	3	1.6
5	142	22.6	703	29.0	294	31.3	139	34.4	55	28.8
6	249	39.6	863	35.6	307	32.7	122	30.2	43	22.5
7	25	4.0	89	3.7	34	3.6	18	4.5	9	4.7
8	25	4.0	167	6.9	55	5.9	25	6.2	16	8.4
9	24	3.8	95	3.9	29	3.1	7	1.7	10	5.2
Total	628	100	2425	100	940	100	404	100	191	100

Note. Chi-Square = 139.760*, ($p = .000$).

Table 3
Serve placement zone by serve zone

Placement zone	BZ1		BZ5		BZ6		Total	Total
	Count	(%)	Count	(%)	Count	(%)		
1	573	22.9	235	19.5	179	20.4	987	21.5
2	8	.3	6	.5	2	.2	16	.3
3	13	.5	9	.7	6	.7	28	.6
4	7	.3	1	.1	4	.5	12	.3
5	654	26.1	398	32.9	281	32.0	1333	29.1
6	916	36.6	385	31.9	283	32.3	1584	34.5
7	92	3.7	49	4.1	34	3.9	175	3.8
8	156	6.2	80	6.6	52	5.9	288	6.3
9	84	3.4	45	3.7	36	4.1	165	3.6
Total	2503	100	1208	100	877	100	4588	100

Note. Chi-Square = 34.880*, ($p = .004$).

SERVE QUALITY by SCORE TREND - It was found that serve quality is not significantly different in the various set phases.

SERVE QUALITY by SET OUTCOME - Contingency analysis (*Chi-Square test*) revealed statistically significant differences ($p = .000$) between set winners and set losers by serve quality. Relative frequencies showed that both *Winner* and *Loser* groups of teams were able to organise all attacks on most serves (*Winner* teams 49.8%, *Loser* teams 56.6%), and on a small percentage it was possible to organise only a third tempo attack (*Winner* teams 21.3%, *Loser* teams 19.4%). The same comparison of the *Winner* and *Loser* groups showed that the winning group significantly made fewer serve errors (13.0% compared to 14.6%), executed fewer serves that permitted all types of attack, performed more serves that compelled the opponent to organise a third tempo attack, provoked more free balls from the opponent (10.4% compared to 6.8%), and made more aces (5.4% compared to 2.6%).

Serve zone was analysed in relation to three criteria: in-game role, score trend, and set outcome.

SERVE ZONE by IN-GAME ROLE - A significant difference ($p = .000$) was observed in the contingency analysis of serve zone by in-game role (Figure 3). Relative frequencies indicate that from behind zone 1, the most used zone, *Opposite* performed 69.2% of total serves by this in-game role, *setter* 63.2% and *outside hitter* 64.4%, whereas *middle blocker* in-game role had the lowest percentage of serves from this zone (30.9%). *Middle blocker* was unique in performing the highest percentage of serves from BZ5 (46.9%) and the lowest percentage from BZ1.

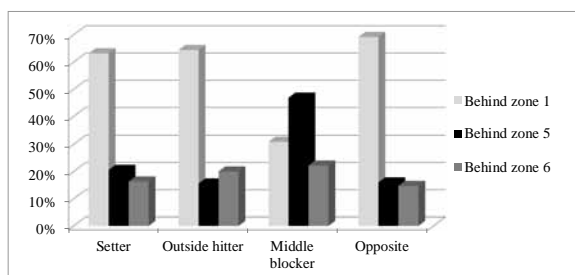


Figure 3. Serve zone distribution by in-game role.

SERVE ZONE by SCORE TREND - The choice of serve zone did not change significantly during the various set phases.

SERVE ZONE by SET OUTCOME - Set *Winner* and set *Loser* groups showed significant differences ($p = .000$) in the zones they served from. Set *Winner* group performed 2554 serves, compared to 2034 serves by set *Loser* group. In terms of relative frequencies, in all phases the set *Winner* and set *Loser* teams performed 54.6% of serves from BZ1, 26.3% from BZ5 and considerably fewer from BZ6 (19.1%). Set *Winner* teams performed considerably more serves (21.5%) from BZ6 than set *Loser* teams (16.2%). As a rule, set *Loser* teams executed more serves (57.2%) from BZ1 than set *Winner* teams (52.4%). Both groups performed almost the same number of serves from BZ5 (*Winner* teams 26.1%, *Loser* teams 26.6%).

Placement zone was analysed in relation to three criteria: serve quality, serve zone and set outcome.

PLACEMENT ZONE by SERVE QUALITY - Statistical analysis showed a significant difference between placement zone and serve quality ($p = .000$). Relative frequency analysis revealed that zones 1, 5 and 6 were the most frequent placement zones (Table 2). The highest number of *Serve Errors* were made in serves to zone 6 (39.6%), compared to values of 25.0% for *Serve Errors* to zone 1 and 22.6% to zone 5. The easiest serves were performed to zone 6 (35.6%), followed by zone 5 (29.0%). Serves that triggered opponent third tempo attack were directed to zones 5 (31.3%) and 6 (32.7%). The highest number of free balls (34.4%) and aces (28.8%) resulted from serves to zone 5.

PLACEMENT ZONE by SERVE ZONE - Contingency analysis showed a significant difference between placement zone and serve zone ($p = .004$). In table 3, relative frequencies show that from BZ5 to zone

5 (32.9%) and zone 6 (31.9%), and from BZ6 to zone 5 (32.0%) and zone 6 (32.3%), players served in almost the same percentage. For serves executed from BZ5 to zone 1 the value was 19.5% and from BZ6 to zone 1 the value was 20.4%, whereas from BZ1, players mostly served to zone 6 (36.6%), then to zone 5 (26.1%) and zone 1 (22.9%).

PLACEMENT ZONE by SET OUTCOME - The only data for which no significant differences were found between the *Winner* and *Loser* groups of teams in any set phase were for serve placement zone.

Discussion

Analysis of relations between the variables used in this study revealed many significant results. For serve type, a clear trend of an increase in the use of JFS was observed, in agreement with the study by Moreno et al. (2007). Jump Float Serve was used in more than 60.0% of serves, followed by a value of 34.9% for JSS and only 4.6% for OFS, indicating that the new rules tested probably caused the predominance of JFS. This concurs with studies by Häyrynen et al. (2007) and Tsvika and Papadopoulou (2008), who found JFS to be the predominant serve type. In contrast, Mackenzie et al. (2012) identified JSS and JFS as the main serve types in elite volleyball. Other authors (Callejón-Lirola, 2006; Ciuffarella et al., 2013) reported JSS as the most frequent serve, followed by JFS and OFS. Analysis of male players under 16 years of age in the study by Gil-Arias, Claver, Fernández-Echeverría, Moreno, and Moreno (2016) showed a higher value for serve with jump (56.6%) than serve from the ground with no jump (43.4%).

Analysis of **SERVE TYPE by IN-GAME ROLE** revealed the following trend of relative frequencies for each in-game role: setters and middle blockers had a higher use of *JFS* (77.3% and 71.6%) while the most frequent serve by opposite players was *JSS* (72.0%). Outside hitters frequently served using *JFS* (54.9%), closely followed by *JSS* (44.7%). Outside hitter and middle blocker were the only in-game roles to perform a similar number of serves (1531 and 1411). The lowest number of serves (692) performed by opposite can be explained by the high number of serve errors and the lack of opportunity to serve several times in a row, for example like the setter (953 serves). Middle blocker was the leader in executing *OFS*, which made up 13.5% of total serves by this in-game role. The literature includes several studies about the serve and in-game role, but they are not comparable with this study because they are about women's and youth volleyball. Fernández-Echeverría et al. (2015) compared in-game role and serve. Although their study was about U14 and U16 female players, it is interesting to note the tendency among younger players. It seems that most teams decide to try to attack with *JFS*, which statistically provokes fewer errors but still creates problems for receivers.

For the relation between **SERVE TYPE** and **SCORE TREND**, there is no parallel literature for comparison. It was found that in most sets, the frequency of *JFS* increased (*Early* phase 55.8%, *Middle* phase 62.9%, *Final* phase 64.0%). In contrast, the frequency of *JSS* decreased with the approach to the *Final* phase (*Early* phase 40.2%, *Middle* phase 32.6%, *Final* phase 30.6%). *Overhead Float Serve* showed a similar trend to *JFS*, increasing in frequency with the approach to the *Final* phase (*Early* phase 3.9%, *Middle* phase 4.5%, *Final* phase 5.4%).

The third correlation between **SERVE QUALITY** and **SERVE ZONE** showed that the highest quality serve was from BZ1 (54.6%), with the highest number of aces and free balls, followed by BZ5 (26.3%), while BZ6 was the zone from where fewest serves were performed (19.1%). Callejón-Lirola (2006) and Moreno et al. (2007) found that the highest percentage of serves (46.7% and 67.2%) are performed from BZ1, concurring with this study. Moreno et al. (2007) reported that the lowest percentage of serves (7.40%) are performed from BZ5, and Callejón-Lirola (2006) reported 21.0% for the same serve zone. In the study by Gil-Arias, Claver, Fernández-Echeverría, Moreno, and Moreno (2016), the most performed serve (35.7%) at the Championship in 2005 was with maximum opponent attack options, whereas the most performed serve (37.3%) at the Championship in 2010 was with

limited attack options for the opponent.

From the analysis of SERVE QUALITY by IN-GAME ROLE, the results for *Outside hitter* and *Middle blocker* in-game roles indicate that these positions are safe servers, because their serves led to the highest percentage of *First tempo* attacks (54.7% and 58.5%) and achieved the lowest percentage of aces (3.9% and 3.0%) and *Free balls* (7.9% and 7.6%). *Outside hitter* was responsible for more serve errors (15.9%) than *Middle blocker* (10.4%) because of the higher relative frequency of JSS (44.7% compared to 14.7%). The term constantly offensive serve can be applied to *Setter* in-game role, as their serves resulted in the most *Third tempo* attacks (25.6%) and *Free balls* (11.0%). *Opposite* in-game role caused the lowest percentage of *First tempo* attack (40.0%) and the highest percentage of aces (7.4%). *Opposite* in-game role can be described as a highly offensive serving position, because these players achieved most aces, caused a high number of free balls (10.1%) and third tempo attacks (19.9%) and made the minimum number of serves that let the opponent organise a *First tempo* attack. Because of this highly offensive serve, *Opposite* in-game role made the most serve errors (22.5%). According to Callejón-Lirola (2006) and Ciuffarella et al. (2013), JSS is the serve with the most errors but also the most aces. Raiola et al. (2016) found no dependence between the relative number of aces and serve type.

For QUALITY OF SERVE by SET OUTCOME, set *Winner* teams had clearly better results in all serve aspects, concurring with the study by Marcelino et al. (2008), who found that the number of serve errors and percentage of serve points are associated with the team's tournament ranking. Claver et al. (2013) found the same trend of winner teams showing higher performance in the serve. In this study the total points won by serve were 4.2%, compared to the findings of Marcelino and Mesquita (2006) in their study of high level volleyball, who reported only a mean value of 4.98 ± 2.87 points won by serve per match. In their study of men's volleyball Palao, Manzanares, and Valadés (2015) found, as a rule, that the set *Winner* teams score 1-2 points per set. Set *Winner* teams had a lower percentage of serve errors (13.0% compared to 14.6%) and a higher percentage of aces (5.4% compared to 2.6%), partly concurring with Marcelino et al. (2008), who found that the best teams fail a higher number of serves but win more points with this action. In this study, set *Winner* teams made slightly fewer serve errors (13.0%) than the value of 14.6% found by Häyriinen et al. (2004), who reported more serve errors for the *Loser* teams (16.6% compared to 18.6%). This study showed that all types of attack could be organised (*first tempo* attack) from 52.9% of serves performed. Moreno et al. (2007) found a value of 52.4%. Further differences between the two studies were 19.2% for serve error reported in this study compared to 13.7% by these authors, 5.8% for aces compared to 4.2%, and 5.3% for serves resulting in a free ball compared to 8.8%.

For SERVE ZONE by IN-GAME ROLE, it was found that *Opposite* players, with the highest percentage of JSS (72.0%), performed most serves from BZ1 (69.2%), probably because it is directly in front of the area where this position plays (zones 2 and 1). Also, immediately after the powerful jump and hit during the serve, it is usual for these players to land in their defence zone (zone 1), otherwise they would need to make additional movements to reach this zone. *Opposite* is the in-game role with minimum zone change. The small percentage of serves from BZ5 (16.0%) and BZ6 (14.7%) could be from left-handed *Opposite* players. *Setter* and *Outside hitter* varied serve zones much more than *Opposite*. *Outside hitter* in-game role served slightly more from BZ6 (20.0%), probably because of the move to the usual defence zone of this position immediately after the serve. *Middle blocker* in-game role showed the most variety in serve zones, with the highest percentage from BZ5 (46.9%), where this player is in the right defence zone (zone 5) after landing. The high percentage of JFS performed from BZ1 (30.9%) by *Middle blocker* in-game role indicates that these players did not find it difficult to move to their defence zone (zone 5). Gil-Arias et al. (2016) found the highest percentage of serves were performed from BZ1 (51.6% in 2005, 50.8% in 2010), followed by BZ6 (33.5% in 2005, 27.3% in 2010) and BZ5 (14.9% in 2005, 21.9% in 2010).

For SERVE ZONE by SET OUTCOME there is no literature for comparison. This analysis showed that, as a rule, both *Winner* and *Loser* group of teams served mostly from BZ1, followed by BZ5 and BZ6. Set *Winner* performed 520 more serves than *Loser* group. In percentages, *Loser* teams performed more serves from BZ1 (57.2% compared to 52.4%) and BZ5 (26.6% compared to 26.1), whereas set *Winner* teams performed more serves from BZ6 (21.5% compared to 16.2%).

For PLACEMENT ZONE by SERVE QUALITY, the total of 4.2% aces performed is divided as follows: 28.8% to zone 5, 23% to zone 1 and 22.5% to zone 6. Ciuffarella et al. (2013) reported 5.62% of aces, divided as follows: 35.5% to zone 6, 18.4% to zone 5 and 16.4% to zone 1. The 22.5% of aces in zone 6 confirms that most *Serve Errors* (39.6%) were made by serving to this zone. The results indicate that zone 5 is the most effective zone to serve to. Gil-Arias et al. (2016) found that the zone most served to was zone 6 (53.9% in 2005, 49.5% in 2010), followed by zone 5 (24.0% in 2005, 31.3% in 2010) and zone 1 (17.82% in 2005, 15.8% in 2010). Other authors reported the equivalent zones most served to. Callejón-Lirola (2006) indicated the following order: zone 6 (33%), zone 1 (15.2%), zone 5 (16.0%), zone 8 (14.8%), zone 9 (8.3%) and zone 7 (9.5%). Ciuffarella et al. (2013) found that in zone 6, the most hit zone, 83.5% of serves were directed by JSS, 14.2% by JFS and 2.3% by OFS. Moreno et al. (2007) reported that most serves (36.45%) go to zone 6, followed by zone 5 (21.8%) and zone 1 (17.73%). In this study the following values were found for serving to zones 7 (3.8%), 8 (6.3%) and 9 (3.6%), and Moreno et al. (2007) reported a value of 23.94% for all three zones.

Analysis of PLACEMENT ZONE by SERVE ZONE, also known as serve direction, showed that the most frequent serve direction from BZ1 was to zone 6 (36.6%), followed by zone 5 (26.1%). From BZ5 the most frequent serve direction was to zone 5 (32.9%), followed by zone 6 (31.9%), and from BZ6 it was to zone 6 (32.3%) and zone 5 (32.0%). The value for serves performed from BZ1 to zone 1 was 22.9%, from BZ5 to zone 1 19.5% and from BZ6 to zone 1 20.4%, which partially agrees with the results from the study by Moreno et al. (2007), who found almost half this value for serves from BZ1 to zone 1 (12.76%) and almost the same from BZ5 and BZ6 to zone 1, at about 20.0%. Gil-Arias et al. (2016) found medium diagonal to be the most frequent serve direction (57.7% in 2005, 53.0% in 2010), followed by parallel (28.4% in 2005, 31.6% in 2010) and long diagonal (13.9% in 2005, 15.3% in 2010).

No significant differences were found for the relations SERVE ZONE - SCORE TREND, QUALITY OF SERVE - SCORE TREND and PLACEMENT ZONE - SET OUTCOME and no studies analysing the relations between these variables were found.

Conclusions

At the Volleyball Men's U23 World Championship, *Jump Float Serve* was the predominant serve type under the new rules tested. *Setter*, *middle blocker* and *outside hitter* in-game roles mostly used *Jump Float Serve*, whereas *opposite* in-game role mostly performed *Jump Spin Serve*. This serve type appears to be a safe but complex weapon that becomes more frequent towards the end of the set, compared to *Jump Spin Serve*, which decreased in frequency with the approach to the *Final* phase. The highest quality serves were performed from behind zone 1, resulting in the greatest number of aces and free balls. *Outside hitter* and *middle blocker* were found to be safe servers, whereas *setter* was a constantly offensive server. *Opposite* was a highly offensive serving position, with the most aces and errors. To win the set, the team has to perform controlled serves but also attack with minimum errors, ensuring their serves result in as few first tempo attacks as possible. It was observed that most servers performed the *Jump Float Serve* after both types of time out, indicating that most teams wanted to ensure a safe serve inside the court. Set *Winner* teams had clearly better results in all serve aspects than set *Loser* teams. *Middle blocker* was found to be the in-game role that used the greatest

combination of serving zones, followed by both setter and outside hitter, whereas opposite in-game role mostly served from behind zone 1. Serving more from behind zone 6 and slightly less from behind zones 1 and 5 were significant characteristics for set *Winners* compared to set *Losers*. Set *Winners* often deployed their servers among three serving zones. Most serves were executed from behind zone 1 to zone 6 (medium diagonal) and zone 5 (parallel). If these rules become part of the official volleyball rules, this study will be a helpful guide for building team tactics and strategy. It also provides insight for FIVB about the effect of the tested rules for further developments in the game.

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