

The influence of serve on the organisation of the block in high-level volleyball across genders

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Published online: April 30, 2025

Accepted for publication: April 15, 2025

DOI:10.7752/jpes.2025.04086

Abstract

This study aimed to investigate the influence of serve characteristics (type, zone, and direction) on block organisation (single, double, triple, open double, no block) in high-level volleyball, and to explore potential gender-based differences in these tactical interactions. The study sample comprised 32 games (16 male, 16 female) from the World Championships 2022. A total of 4,289 serves were analysed, using a six-level (0-5) tactical rating scale. Intra and inter-rater reliability were assessed using Cohen's K Index, which showed high consistency (>0.8). The chi-square test and Fisher's exact test were used to analyse the independence of categorical variables, with statistical significance set at $p < 0.05$. The results of the study indicated that the most common block type for both genders was the double block. Male athletes executed single, double, and triple blocks more frequently, predominantly using the powerful jump serve (PJS) from serving areas SA1 and SA6, while directing it primarily toward the centre of the court (CM). Female athletes performed double and open double blocks more frequently, using the float jump serve (FJS) from SA1 and SA5, directing them toward the areas near the baseline or the sidelines. Women performed double blocks more frequently, irrespective of the athletes' in-game role. In contrast, when male outside hitters and opposites served, their teams formed triple blocks more frequently than women. Following serves from middle blockers and setters, men primarily performed single and triple blocks. Males used PJSs to disrupt the opposing attack, leading to triple, single, or no blocks. In conclusion, post-serve blocking strategies displayed a clear gender-based difference, while serve type emerged as a key factor influencing block organisation.

Keywords: serve performance, block type, serve type, match analysis, chi-square

Introduction

Volleyball is a widely popular sport, with over 800 million players worldwide, according to FIVB. A key aspect of the game is mastering scoring skills, such as powerful attacks, strategic serves, and well-timed executed blocks. These skills not only improve a player's performance but also contribute to the excitement and competitiveness of the sport.

In volleyball, the serve is the first action that occurs both chronologically and tactically. It is the first action of the game, but also of every subsequent game episode, and the only action in volleyball that does not depend on any other. As serve is an attacking action, it is considered one of the performance indicators in volleyball, alongside the attack and block (Marcelino et al., 2008). The primary aim of a serve is to win the point directly or to challenge the opponent's reception as much as possible (Raiola, 2014). There are five different types of serve: the powerful jump serve, the placed jump serve, the sharp fast jump float serve, the float jump serve and the float serve without a jump (Costa et al., 2012). The powerful jump serve (PJS) is the riskiest one, showing an error rate of 21.7%, with 1 in 5 resulting in a fault. In contrast, other serve types exhibit a fault ratio of 1 in 12 (Ciuffarella et al., 2013). However, high-level teams are eager to take this risk due to its effectiveness; after a PJS, they face fewer first-tempo attacks compared to other types of serve. Researchers have found that 15.3% of PJSs are difficult for the opponents' reception (Ciuffarella et al., 2013). Previous research has also identified some variations in the service direction, according to the service type. PJSs are mainly directed to the centre of the court, while FJSs are mainly directed to areas near the sidelines, aiming to challenge the outside hitter of the front zone and prevent them from attacking (Barzouka et al., 2021).

The choice between the different types of serve depends not only on the individual characteristics of each player but also on the team's strategy, aiming to exploit the weaknesses of the opponent. The tactical plan of the team affects also the direction of the serve. It has been shown that women's teams mainly use the float serve, either with or without a jump (Kitsiou et al., 2020; Palao et al., 2009). In men's teams, two are the most dominant types of serve, the powerful jump serve (PJS) and the float jump serve (FJS). Men primarily use the PJS at a rate of 69.9%, followed by the FJS at 26.9% and the float serves without jump (FS) at only 3.3% (Ciuffarella et al., 2013). In contrast, women mostly use the FJS (93.3%), followed by the PJS (4.9%) and FS (1.8%) (Barzouka et

al., 2021). Choosing the service type is further influenced by the athlete's specialization. For example, middle blockers and setters tend to use FJS and FS, while opposites and outside hitters very often opt for the PJS (Quiroga et al., 2010). Regarding the execution zone, both genders mainly choose to serve from service area 1 (SA1) (Barzouka et al., 2021). Specifically, men serve from SA1 at a rate of 56.5%, while women serve from SA1 at a rate of 48.4% and from SA5 at a rate of 44.8% (Kitsiou et al., 2020). SA1 is the predominant choice for female setters, opposites, and outside hitters, whereas middle blockers mainly serve from SA5 (Quiroga et al., 2010). Similarly, in men's teams, the most frequently observed serve area is SA1 with a PJS, followed by SA5, primarily for jump float serves (Stamm, Stamm, Torilo, et al., 2016).

Blocking, as identified by Marcelino et al. (2008), constitutes a key performance indicator in volleyball, functioning as the primary defensive action (Afonso & Mesquita, 2011). In high-level teams, blocking is considered the most important skill deployed against the opposing team's attack (Palao et al., 2004). Blocking performance is also associated with the individual characteristics of each athlete, such as their speed and their ability to predict the direction of the ball (Hernández-Hernández et al., 2020; Xu, 2020). Additionally, the formation of the block is strongly influenced by the opponent's game and specifically by the setting type, the setting zone, and the setting tempo chosen for the attack (Gonzalez-Silva et al., 2017). Middle blockers are the ones who have the greatest participation in the team's block, as their position in the middle of the net allows them to execute blocks over the entire length of the net. They perform 45.5% of a team's total block jumps during a game (Lobietti & Merni, 2006). Both men and women mainly perform single (29.3%) or double (32.1%) blocks (Araújo et al., 2009). Male teams are more likely to face double and triple blocks than females, especially when attacking from zone 1 (Tsavdaroglou et al., 2018), perhaps because of the active role of the opposite attacker in their offensive plan. In contrast, female teams attack more often without block, which can be explained by the different roles of the opposite attackers in their game. In the women's game, opposites are frequently used as a safety option and therefore receive many settings from disrupted reception and defense (Sotiropoulos, Drikos, & Barzouka, 2021). As a result, the women's game is more predictable for the opposing block, which has enough time to form up in the right position, as the team's offensive options are fewer. Similarly, male opposites are also responsible for attacking the so-called broken balls and are therefore often face triple blocks when attacking from zone 1 (Tsavdaroglou et al., 2018). Many studies have analysed the skills of serve and block (Barzouka et al., 2021; González-Silva et al., 2020; Kitsiou et al., 2020; Tsavdaroglou et al., 2018) as the serve is the first contact in a rally and the block is the immediate response to the opponent's attack. The serving team sequentially executes serve and block. However, this sequence is disrupted by the opposing team's offensive game, which aims to neutralize the serve and execute unpredictable attacks. When the serve is ineffective, the sequential link between serve and block is weakened, leading to defensive vulnerabilities. This leads to a complex interplay that needs further investigation (Araújo et al., 2009).

In conclusion, although the skills of serving and blocking have been extensively researched, there are no studies investigating the sequential relationship between the two. This study hypothesized that there will be a significant relationship between serve characteristics (type, zone, and direction) and the type of block organization employed by the serving team in high-level volleyball across genders. Also, there will be significant gender-based differences in the relationship between serve characteristics and block organization. Specifically, it is hypothesized that male players will exhibit different blocking strategies in response to varying serve characteristics compared to female players. For example, it is expected that men will utilize triple blocks more frequently than women, particularly against powerful jump serves.

This study aimed to investigate the influence of serve characteristics (type, zone, and direction) on block organization (single, double, triple, open double, no block) in high-level volleyball, and to explore potential gender-based differences in these tactical interactions.

Materials and methods

Thirty-two games (16 male and 16 female) from the World Championship of 2022 were analysed. The sample consisted of 5556 serves, of which N=4289 were evaluated. In the remaining actions, the serving team either won the point or lost the serve. Data was collected through systematic observation and recorded on a Microsoft Office Excel spreadsheet. The study variables were the following: gender (Female, Male), serve type (Power Jump Serve-PJS, Float Jump Serve-FJS, Standing Float Serve-FS), block type (single, double, triple, open double, open triple, no block because of opponent setter's skillfulness, no block-because of tactic choice in a disorganised attack), the in-game role of the player (S=setter, OH1=outside hitter next to S, OH2=outside hitter far from S, MB1=middle blocker next to S, MB2= middle blocker far from S, OPP=opposite) serve execution area and serve direction according to the Figure 1 (Sotiropoulos, Drikos, Papadopoulou, et al., 2021).

The evaluation of the serve was based on a six-point rating scale (0-5) (Drikos et al., 2019; Misikin et al., 2010; Rocha & Barbanti, 2006). This scale rates the serve as follows: Quality Level 0 (QL0)=serve error, QL1=the receiving team has all attacking options, QL2= the receiving team does not have all attacking options, QL3= the receiving team has limited attacking options, QL4= freeball for the serving team, QL5=serve scores a point (ace). Serves categorised as 0 and 5 were not included in the study. The dependent variable of the study was the block type (the number of blockers and the cohesion of the block). In contrast, the independent variables

were: gender, serve performance, serve type, serve execution zone, serve direction, and in-game role of the server). Two experienced and trained observers conducted video analysis. To ensure reliability, a test-retest procedure was performed within a 4-week interval, on 10% of the games, meeting the minimum value recommended in the literature (Tabachnick et al., 2019). The researcher's intra and inter-observer reliability was assessed using Cohen's Kappa index (Cohen, 1988), which showed values of $>.8$, indicating a high reliability (Altman, 1991).

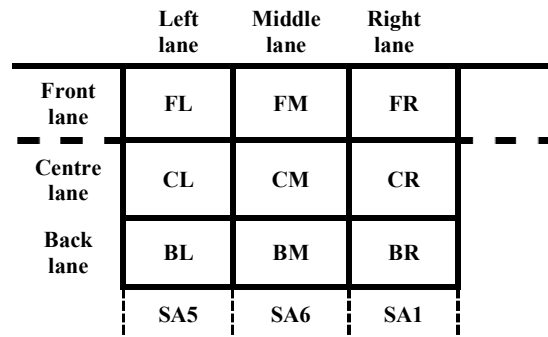


Figure 1. Nine-area subdivision of the volleyball court used to define the area of the serve direction. The dashed lines represent a three-area subdivision of the serve position.

The statistical analysis used was a) test of independence between “serve variables” and “block type” per gender. Additionally, a proportion equality test was used to examine the equality of performance ratios between men and women per block type concerning each category of serve variable. The same procedure was used for all the variables. SPSS v.23 and Statgraphics v.5.1 were used to conduct all the analyses, with the significance level set at $p<0.05$.

Results

The chi-squared test results indicated that there is a significant association between the block type and the serve performance in both men ($\chi^2=874.786$, $df=18$, $p<0.000$) and women ($\chi^2=435.839$, $df=18$, $p<0.000$). Table 1 presents the block type concerning serve performance per gender. From the total number of serves, the serves categorised as 0 and 5 were excluded. The majority of serves for both genders were QL1 (F=67.3% and M=69.5%), while the least observed were the QL4 (F=2.5% and M=1.8%). The results indicated a difference in the frequency of occurrence of QL3 serves between men and women ($z=2.06$, $p=0.04$). The analysis showed a statistically significant difference between genders, regarding the impact of serve performance on block organization. Specifically, when men's serves were QL1, they formed single and triple blocks more frequently than women ($z=-7.57$, $p=0.001$ and $z=-4.16$, $p=0.001$), whereas women performed double and open double blocks more often than men ($z=5.57$, $p=0.001$ and $z=3.29$, $p=0.001$). When the serves were QL2, men executed triple blocks more frequently than women ($z=-4.95$, $p=0.001$). Following a QL3 serve, men formed triple and open triple blocks more frequently than women ($z=-11.8$, $p=0.001$ and $z=-3.31$, $p=0.001$), who mostly formed double and open double blocks ($z=7.89$, $p=0.001$ and $z=4.04$, $p=0.001$). Finally, when the serve quality was categorised as QL4, men performed single blocks more frequently than women ($z=-2.32$, $p=0.02$), who primarily performed double blocks ($z=1.92$, $p=0.05$).

Table 1. Block type in relation to serve performance per gender

Serve Performance	Gender	Block type							Sum
		Single	Double	Triple	Open double	Open triple	NoBl-St	NoBl-Tactic	
QL1	F	25.1(374)	36.7(546)	0.4(6)	33.3(496)	0.8(12)	2.6(39)	1.1(16)	1489
	M	38.1(550)	26.8(386)	2.1(31)	27.7(399)	0.8(12)	3.3(47)	1.2(17)	1442
	<i>z</i>	-7.57	5.75	-4.16	3.29	0	-1.12	-0.25	
	<i>p</i>	0.001	0.001	0.001	0.0009	ns	ns	ns	
QL2	F	12.8(47)	57.7(211)	2.7(10)	23.2(85)	0.8(3)	0.8(3)	1.9(7)	366
	M	9.3(33)	53.2(189)	12.4(44)	18.9(67)	3.9(14)	0.3(1)	2(7)	355
	<i>z</i>	1.5	1.21	-4.95	1.41	-2.76	0.9	-0.1	
	<i>p</i>	ns	ns	0.001	ns	0.006	ns	ns	
QL3	F	8.6(26)	60.5(184)	3.3(10)	14.5(44)	0.7(2)	0.3(1)	12.2(37)	304
	M	5(12)	26.6(64)	45.2(109)	4.1(10)	5.4(13)	0.0(0)	13.7(33)	241
	<i>z</i>	1.63	7.89	-11.8	4.04	-3.31	-	-0.52	
	<i>p</i>	ns	0.001	0.001	0.001	0.0009	ns	ns	

QL4	F	16.4(9)	27.3(15)	0.0(0)	16.4(9)	0.0(0)	3.6(2)	36.4(20)	55
	M	37.8(14)	10.8(4)	13.5(5)	16.2(6)	0.0(0)	2.7(1)	18.9(7)	37
	z	-2.32	1.92	-	0.02	-	2.24	1.81	
	p	0.02	0.05	ns	ns	ns	ns	ns	
Sum	F	20.6(456)	43.2(952)	1.2(26)	28.6(634)	0.8(17)	2(45)	3.6(80)	2214
	M	29.3(609)	31(643)	9.1(189)	23.2(482)	1.9(39)	2.4(49)	3.1(64)	2075
	z	-6.59	8.26	-11.8	4.03	-3.14	-0.89	0.91	
	p	0.001	0.001	0.001	0.001	0.002	ns	ns	

Regarding the association between serve type and block type for males, a chi-squared test showed that there is a significant association ($\chi^2=50.726$, $df=12$, $p<0.001$). Regarding females, a chi-squared test showed that block type and serve type are independent ($\chi^2=4.988$, $df=12$, $p=0.958$). Male players utilized the PJS more often than female ($z=-45.6$, $p=0.001$), who used the FJS ($z=27.2$, $p=0.001$) and FS more often (F: $N=115$ and M: $N=1$). A follow-up comparison between genders concerning ratios of each block type for each serve type is presented in Table 2. The analysis revealed that when women used the PJS, they performed double, open double, and single block more frequently than men ($z=1.94$, $p=0.05$, $z=2.19$, $p=0.03$, and $z=1.87$, $p=0.06$ respectively), who performed more frequently triple blocks ($z=-3.67$, $p=0.001$). Furthermore, when employing the FJS serve, men performed single and triple blocks more frequently than women ($z=-8.26$, $p=0.001$ και $z=-5.52$, $p=0.001$), who predominantly performed double blocks ($z=8.13$, $p=0.001$). When teams used the FS serve, no gender differences were observed, as the number of FS by men was negligible.

Table 2. Block type concerning serve type by gender

Serve Type	Gender	Block Type							Sum
		Single	Double	Triple	Open double	Open triple	NoBl-St	NoBl-Tactic	
PJS	F	20.2(38)	40.4(76)	2.1(4)	29.3(55)	0.5(1)	2.7(5)	4.8(9)	188
	M	26.5(425)	33.3(533)	10.4(167)	22.2(356)	2(32)	2.4(39)	3.1(49)	1601
	z	1.87	1.94	-3.67	2.19	-1.45	0.25	1.24	
	p	0.06	0.05	0.0002	0.03	ns	ns	ns	
FJS	F	20.7(396)	43.4(829)	1(20)	28.5(545)	0.8(16)	2(38)	3.5(67)	1911
	M	38.9(184)	23(109)	4.7(22)	26.6(126)	1.5(7)	2.1(10)	3.2(15)	473
	z	-8.26	8.13	-5.52	0.82	-1.41	-1.14	0.32	
	p	0.001	0.001	0.001	ns	ns	ns	ns	
FS	F	19.1(22)	44.3(51)	1.7(2)	29.6(34)	0.0(0)	1.7(2)	3.5(4)	115
	M	0.0(0)	100(1)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	1
	z	-	0.69	-	-	-	-	-	
	p	ns	ns	ns	ns	ns	ns	ns	
Sum	F	20.6(456)	43.2(956)	1.2(26)	28.6(634)	0.8(17)	2(45)	3.6(80)	2214
	M	29.3(605)	31(643)	9.1(189)	23.2(482)	1.9(39)	2.4(49)	3.1(64)	2075
	z	-6.59	8.25	-11.8	4.03	-3.14	-0.89	0.91	
	p	0.001	0.001	0.001	0.001	0.002	ns	ns	

The chi-squared test results showed that, for male players, there is a statistically significant relationship between the block type and the serve execution area ($\chi^2=27.594$, $df=12$, $p<0.006$). However, for female players, a chi-squared test showed that block type and the execution area of the serve are independent of each other ($\chi^2=9.819$, $df=12$, $p<0.632$). Table 3 presents the block type concerning the serve execution area for men and women. Both men and women predominantly served from SA1, followed by SA5 for women and SA6 for men. Women exhibited a higher frequency of serves from SA1 and SA5 compared to men ($z=2.18$, $p=0.03$ and $z=5.91$, $p=0.001$), who mostly served from SA6 ($z=-9.12$, $p=0.001$). The analysis revealed some gender-based differences. When serving from SA1, men performed single, double, and open triple blocks more frequently than women ($z=-3.93$, $p=0.001$, $z=-7.30$, $p=0.001$ and $z=-2.58$, $p=0.009$ respectively), whereas women predominantly performed double and open double blocks ($z=3.76$, $p=0.001$ and $z=3.33$, $p=0.001$ respectively). On the other hand, when serving from SA6, men performed more single and triple blocks ($z=-2.67$, $p=0.007$, $z=-3.70$, $p=0.001$), while women showed a higher frequency of double blocks ($z=3.70$, $p=0.001$). Additionally, when serving from SA5, men formed single and triple blocks more frequently ($z=-4.53$, $p=0.001$, $z=-6.94$, $p=0.001$), while women mostly performed double blocks ($z=7.06$, $p=0.001$).

Table 3. Block type concerning the serve execution zone by gender

Serve Zone	Gender	Block Type							Sum
		Single	Double	Triple	Open double	Open triple	NoBl-St	NoBl-Tactic	
SA1	F	19.6(196)	42.7(427)	1.4(14)	29.5(295)	0.9(9)	1.8(18)	4.2(42)	1001
	M	27.3(237)	34.2(297)	8.6(75)	22.7(197)	2.4(21)	1.5(13)	3.2(28)	868
	z	-3.93	3.76	-7.3	3.33	-2.58	0.51	1.14	
	p	0.001	0.001	0.001	0.001	0.009	ns	ns	
SA6	F	22.8(92)	42.8(173)	1.2(5)	26(105)	1.2(5)	2.2(9)	3.7(15)	404
	M	30.4(192)	31.5(199)	10.5(66)	21.4(135)	1.6(10)	2.2(14)	2.4(15)	631
	z	-2.67	3.7	-5.77	1.71	-0.53	0	1.21	
	p	0.007	0.0002	0.001	ns	ns	ns	ns	
SA5	F	20.6(168)	44(356)	0.9(7)	28.9(234)	0.4(3)	2.2(18)	2.8(23)	809
	M	31.3(180)	25.5(147)	8.3(48)	26(150)	1.4(8)	3.8(22)	3.6(21)	576
	z	-4.53	7.06	-6.94	1.19	-2.04	-1.76	-0.84	
	p	0.001	0.001	0.001	ns	ns	ns	ns	
Sum	F	20.6(456)	43.2(956)	1.2(26)	28.6(634)	0.8(17)	2(45)	3.6(80)	2214
	M	29.3(609)	38.7(724)	4.8(89)	26.3(492)	1.6(30)	1.7(31)	3.7(70)	2075
	z	-6.43	2.91	-6.89	1.64	-2.37	0.95	-0.17	
	p	0.001	0.004	0.001	ns	0.02	ns	ns	

Regarding the association between block type and serve direction for females, a chi-squared indicated, that there is no significant association between them ($\chi^2=67.105$, $df=48$, $p<0.036$). In contrast, for males, the test revealed a statistically significant relationship between block type and the direction of the serve ($\chi^2=79.958$, $df=48$, $p<0.003$). Table 4 presents the block type in relation to the serve direction in men and women. The majority of serves in both men and women were directed towards area BM (Z6, F=31.5%, and M=42.6%). No observed differences were found between genders when they served in areas FR and FL. However, the analysis revealed statistically significant differences when they served in all the other areas. Men predominantly served towards areas BR, FM, BL, and BM ($z=-7.53$, $p=0.001$, $z=-3.06$, $p=0.002$, $z=-7.98$, $p=0.001$, and $z=-7.53$, $p=0.001$ respectively), while women primarily directed their serves towards areas CL, CM, and CR ($z=11.8$, $p=0.001$, $z=11.2$, $p=0.001$, and $z=7.50$, $p=0.001$ respectively). Specifically, when men served toward area BR, they performed single and triple blocks more frequently than women ($z=-2.13$, $p=0.03$, $z=-2.83$, $p=0.005$), who executed more double blocks ($z=3.81$, $p=0.001$). When men directed their serves toward area BL, they performed triple and open triple blocks more frequently than women ($z=-4.36$, $p=0.001$, $z=-1.98$, $p=0.05$), who executed double and open double blocks more often ($z=2.13$, $p=0.03$ and $z=2.51$, $p=0.01$). Furthermore, when men served in area BM, they formed single, triple, and open triple blocks more frequently than women ($z=-3.60$, $p=0.001$, $z=-7.77$, $p=0.001$ and $z=-2.12$, $p=0.03$ respectively), who performed more double and open double blocks ($z=3.75$, $p=0.001$ και $z=3.83$, $p=0.001$). Men also performed single blocks more frequently than women ($z=-4.07$, $p=0.001$) when they directed their serves in area CL, while women executed double blocks more often ($z=3.96$, $p=0.001$). When the service was directed toward area CM, men performed single and triple blocks more often than women ($z=-3.86$, $p=0.001$, $z=-2.32$, $p=0.02$), who performed more double blocks ($z=2.89$, $p=0.004$). Finally, when men directed their serves in area CR, men performed triple blocks more frequently than women ($z=-2.95$, $p=0.003$), who performed more double blocks ($z=3.06$, $p=0.002$).

Table 4. Block type in relation to the serve direction in men and women

Serve Direction	Gender	Block Type							Sum
		Single	Double	Triple	Open double	Open triple	NoBl-St	NoBl-Tactic	
BR	F	19.1(33)	49.1(85)	2.3(4)	22(38)	1.2(2)	2.9(5)	3.5(6)	173
	M	27.7(93)	31.8 (107)	8.9(30)	23.8(80)	2.4(8)	2.1(7)	3.3(11)	336
	z	-2.13	3.81	-2.83	-0.45	-0.92	0.56	0.12	
	p	0.03	0.0001	0.005	ns	ns	ns	ns	
FR	F	0.0(0)	69.2(9)	0.0(0)	15.4(0)	0.0(0)	0.0(0)	15.4(2)	13
	M	14.3(1)	28.6(2)	42.9(3)	0.0(0)	0.0(0)	0.0(0)	14.3(1)	7
	z	-	1.74	-	-	-	-	0.06	

	<i>p</i>	ns	ns	ns	ns	ns	ns	ns	
FM	F	16.7(2)	41.7(5)	8.3(1)	25(3)	8.3(1)	0.0(0)	0.0(0)	12
	M	37.9(11)	24.1(7)	13.8(4)	6.9(2)	0.0(0)	10.3(3)	6.9(2)	29
	<i>z</i>	-1.33	1.13	-0.49	1.61	-	-	-	
	<i>p</i>	ns	ns	ns	ns	ns	ns	ns	
FL	F	25(1)	50(2)	0.0(0)	0.0(0)	0.0(0)	0.0(0)	25(1)	4
	M	33.3(2)	50(3)	0.0(0)	16.7(1)	0.0(0)	0.0(0)	0.0(0)	6
	<i>z</i>	-0.28	-	-	-	-	-	-	
	<i>p</i>	ns	ns	ns	ns	ns	ns	ns	
BL	F	19.9(54)	43.4(118)	1.5(4)	28.7(78)	0.4(1)	1.1(3)	5.1(14)	272
	M	24.8(110)	35.4(157)	9.9(44)	20.5(91)	2.3(10)	2.7(12)	4.5(20)	444
	<i>z</i>	-1.51	2.13	-4.36	2.51	-1.98	-1.45	0.37	
	<i>p</i>	ns	0.03	0.001	0.01	0.05	ns	ns	
BM	F	21.6(151)	39(272)	0.9(6)	32.8(229)	0.6(4)	2.1(15)	3(21)	698
	M	29.6(262)	30(265)	10.4(92)	24.1(213)	1.8(16)	1.9(17)	2.1(19)	884
	<i>z</i>	-3.6	3.75	-7.77	3.83	-2.12	0.28	1.14	
	<i>p</i>	0.0003	0.0001	0.001	0.0001	0.03	ns	ns	
CL	F	17.3(72)	43.9(183)	1.4(6)	30.2(126)	0.7(3)	2.6(11)	3.8(16)	417
	M	33.6(47)	25(35)	3.6(5)	27.9(39)	1.4(2)	5.7(8)	2.9(4)	140
	<i>z</i>	-4.07	3.96	-1.63	0.52	-0.77	-1.76	0.5	
	<i>p</i>	0.001	0.001	ns	ns	ns	ns	ns	
CM	F	21.9(87)	44.7(178)	0.8(3)	26.9(107)	1.3(5)	2(8)	2.5(10)	398
	M	38.6(54)	30.7(43)	3.6(5)	22.1(31)	2.1(3)	0.0(0)	2.9(4)	140
	<i>z</i>	-3.86	2.89	-2.32	1.12	-0.67	-	-0.25	
	<i>p</i>	0.001	0.004	0.02	ns	ns	ns	ns	
CR	F	24.7(93)	45.8(104)	0.9(2)	22.5(51)	0.4(1)	1.3(3)	4.4(10)	227
	M	32.6(29)	27(24)	6.7(6)	28.1(25)	0.0(0)	2.2(2)	3.4(3)	89
	<i>z</i>	-1.42	3.06	-2.95	-1.05	-	-0.58	0.4	
	<i>p</i>	ns	0.002	0.003	ns	ns	ns	ns	
Sum	F	20.6(456)	43.2(956)	1.2(26)	28.6(634)	0.8(17)	2(45)	3.6(80)	2214
	M	29.3(609)	31(643)	9.1(189)	23.2(482)	1.9(39)	2.4(49)	3.1(64)	2075
	<i>z</i>	-6.59	8.26	-11.84	4.03	-3.14	-0.89	0.91	
	<i>p</i>	0.001	0.001	0.001	0.001	0.002	ns	ns	

For male players, the chi-squared test revealed that there is a significant relationship between the block type and the server's specialisation ($\chi^2=56.700$, $df=30$, $p<0.002$). In contrast, for female players, the test showed that block type and server's specialisation are independent ($\chi^2=42.853$, $df=30$, $p=0.060$). Table 5 presents the distribution of block types in relation to the server's specialisation. Double and single blocks were predominant in both genders. However, statistical analysis revealed several gender-based differences in blocking patterns. Men performed single, triple, and open triple blocks at a significantly higher frequency than women ($z=-6.59$, $p=0.001$, $z=-11.8$, $p=0.001$, and $z=-3.14$, $p=0.002$ respectively), while women more frequently performed double and open double blocks ($z=8.25$, $p=0.001$ and $z=-4.03$, $p=0.001$ respectively). Specifically, when OH1 served, men formed triple blocks more frequently ($z=-5.61$, $p=0.001$), whereas women predominantly formed double blocks ($z=2.41$, $p=0.01$). When OH2 served, men executed single blocks more frequently than women ($z=-2.21$, $p=0.03$) who primarily performed double blocks ($z=3.48$, $p=0.001$). In rotations where MB1 served, men performed single and triple blocks more frequently ($z=-4.21$, $p=0.001$ and $z=-4.30$, $p=0.001$), whereas women formed double blocks ($z=5.59$, $p=0.001$). Similarly, when MB2 served, men performed single and triple blocks more frequently ($z=-2.81$, $p=0.005$ and $z=-4.64$, $p=0.001$, respectively), while women either performed double blocks or no blocks due to the quality of the setting ($z=4.72$, $p=0.001$ and $z=2.49$, $p=0.01$ respectively). Furthermore, when opposites served, men performed triple blocks more frequently than women ($z=-4.61$, $p=0.001$), who primarily performed double blocks ($z=2.01$, $p=0.04$). Finally, following a serve from the setter, men executed single and triple blocks more frequently than women ($z=-4.99$, $p=0.001$ and $z=-3.99$, $p=0.001$), who predominantly formed double and open double blocks ($z=2.12$, $p=0.03$ and $z=2.12$, $p=0.001$, respectively).

Table 5. Block type in relation to the server's specialization in men and women.

Player's in-game role	Gender	Block Type							Sum
		Single	Double	Triple	Open double	Open triple	NoBI- St	NoBI- Tactic	
OH1	F	20.6(83)	42.7(172)	1.2(5)	29.5(119)	1.2(5)	1.7(7)	3(12)	403
	M	22.3(78)	34.1(119)	10.6(37)	23.8(83)	2.3(8)	2.6(9)	4.3(15)	349
	Z	-0.57	2.41	-5.61	1.76	-1.16	-0.85	-0.95	
	P	ns	0.01	0.001	ns	ns	ns	ns	
OH2	F	23.7(85)	42.1(151)	0.0(0)	25.6(92)	0.6(2)	2.2(8)	5.8(21)	359
	M	31.2(104)	29.4(98)	9.6(32)	22.2(74)	2.1(7)	1.8(6)	3.6(12)	333
	z	-2.21	3.48	-	1.05	-1.73	0.37	1.36	
	p	0.03	0.0005	ns	ns	ns	ns	ns	
MB1	F	23.7(98)	42.4(175)	0.7(3)	28.1(116)	0.7(3)	1.5(6)	2.9(12)	413
	M	37(137)	23.5(87)	6.2(23)	25.9(96)	1.4(5)	2.4(9)	3.5(13)	370
	z	-4.05	5.59	-4.3	0.69	-0.97	-0.91	-0.48	
	p	0.001	0.001	0.001	ns	ns	ns	ns	
MB2	F	16.9(57)	47.6(161)	1.2(4)	28.4(96)	0.6(2)	3(10)	2.4(8)	338
	M	25.8(85)	29.8(98)	9.1(30)	28(92)	2.1(7)	3.3(11)	1.8(6)	329
	z	-2.81	4.72	-4.64	0.11	-1.68	-0.22	2.49	
	p	0.005	0.001	0.001	ns	ns	ns	0.01	
OPP	F	21.8(69)	40.2(127)	2.8(9)	27.2(86)	0.6(2)	1.9(6)	5.4(17)	316
	M	26.5(87)	32.6(107)	12.5(41)	22(72)	1.8(6)	1.8(6)	2.7(9)	328
	z	-1.39	2.01	-4.61	1.53	-1.39	0.09	1.74	
	p	ns	0.04	0.001	ns	ns	ns	ns	
S	F	16.6(64)	44.2(170)	1.3(5)	32.5(125)	0.8(3)	2.1(8)	2.6(10)	385
	M	32.2(118)	36.6(134)	7.1(26)	17.8(65)	1.6(6)	2.2(8)	2.5(9)	366
	z	-4.99	2.12	-3.99	4.63	-1.01	-0.09	0.09	
	p	0.001	0.03	0.001	0.001	ns	ns	ns	
Sum	F	20.6(456)	43.2(956)	1.2(26)	28.6(634)	0.8(17)	2(45)	3.6(80)	2214
	M	29.3(609)	31(643)	9.1(189)	23.2(482)	1.9(39)	2.4(49)	3.1(64)	2075
	z	-6.59	8.25	-11.8	4.03	-3.14	-0.89	0.91	
	p	0.001	0.001	0.001	0.001	0.002	ns	ns	

Discussion

The purpose of this study was to examine and analyse the influence of serving performance and its technical and tactical characteristics on the organization of the block, in relation to the number of athletes involved in the block formation. Serve performance, serve type, serve position, serve direction, and the in-game role of the server were the variables that were analysed. The present study also aimed to compare block organization between genders to provide insights for the development of specialized training programs for each gender. Regarding the type of block employed, the results showed that both genders tended to use double blocks more often (men 31%, women 43,2%), which confirms the results of previous studies (Araújo et al., 2011) The observed prevalence of double blocks can be attributed to a proportionally elevated rate of serves that negatively impacted the opposing team's reception. This compromised reception efficacy subsequently constrained the setter's ability to utilize the full spectrum of tactical offensive options, leading to an increase in the predictability of their play selection. Although QL2 and QL3 serves accounted for approximately one-third of the total serves performed, they seem to explain 41.5% of women's double blocks and 39.3% of men's double blocks. The remaining ratio of double blocks can be explained by the ability of middle blockers to effectively evaluate and utilise the pre-match available information about their opponent's specific technical and tactical characteristics (Palao & Hernández-Hernández, 2014). Through this information, middle blockers are often able to anticipate the intentions of the opposing setter, even after receptions that allow the team to execute a well-organised attacking plan. Furthermore, considering that QL1 serves were about 70% of the total, it was observed that female middle blockers successfully managed to anticipate the opposing setter's transfer in 36.7% of cases, compared to 26.8% for male middle blockers. This difference between genders can be explained by the type of serves they

predominantly used, since in women the most dominant type was the FJS (86.3%), while in men, it was the PJS (77.2%), confirming the findings of previous studies on the most used types of serves per gender (Barzouka et al., 2021; Ciuffarella et al., 2013; Kitsiou et al., 2020). It is known that the PJS, although it is characterized by a high risk of loss (21.7%), is considered to negatively impact the reception of the opposing team (15.3%) (Ciuffarella et al., 2013). It is also considered to have a crucial effect on the type of opposing block and especially on the number of blockers (Gonzalez-Silva et al., 2017), as it facilitates their efforts to anticipate the attacking zone. However, this only seems to be true in women's games, as it has been found that when female setters do not receive the ball in the ideal area, they set it at a slower tempo, in a way that facilitates the organization of the opposing block (Afonso et al., 2010). In contrast, male setters in high-level teams are capable of setting the ball effectively even under non-ideal conditions (Palao et al., 2005; Papadimitriou et al., 2004), while maintaining the pluralism of their attacking plan and limiting the predictive ability of opposing blockers (Marcelino et al., 2012, 2014). Therefore, it seems that the significant difference in favor of females in the formation of double blocks (~10%), is due to the ability of male setters to organize faster, higher-quality, and more balanced gameplay in each rotation (Barzouka et al., 2019). Gender differences in anthropometric and physical characteristics play a significant role in this. It is known that among equally trained athletes, both upper and lower limb muscle strength of men is significantly higher (Bishop et al., 1987). The above-mentioned ability of male setters to set the ball effectively on a faster tempo more often compared to females (Barzouka et al., 2019) also explains the differences that have been found between them in the frequency of performing single blocks.

The observed near-duplication in the frequency of male athletes executing triple blocks and open triple blocks suggests a gender-based performance differential. This disparity likely stems from the enhanced capacity of male middle blockers to exploit opportunities presented by slower tempo sets (specifically those of the third and second slow tempo), particularly following serves characterized by average quality (QL2 and QL3). The use of triple blocks was more than twice as high in men's games, which can be attributed to the fact that it is a necessary tool in the men's game to deal with the opposing team's powerful attacks, which are more difficult to manage (Afonso et al., 2005; Castro & Mesquita, 2008; Palao et al., 2004). In contrast, the current gameplay of women is characterised by less effective attacks than the men's game (Lima et al., 2019; Sotiropoulos, Drikos, & Barzouka, 2021). For this reason, the game rallies in women's games are noticeably longer (Titov & Steel, 2022). The recent trend in women's gameplay that aims to approach the speed of men's volleyball, can explain the higher frequency of open double blocks in their game. Female setters now use the 2nd slow tempo settings more often, instead of 3rd tempo sets (Barzouka et al., 2019). Indeed, when the reception is excellent or very good, they tend to use fast tempo sets to zone 2, where middle blockers with one step approach and opposites attack at a fast tempo, complicating the formation of a solid double block from the opposite team (Barzouka, 2018).

Additionally, the present study also found that there are differences between genders as serve characteristics as execution zone, direction, and the specialisation of the server, affect block organisation. Specifically, regardless of the execution area of the serve, women more frequently performed double blocks compared to men. Only when serving from SA1 women performed more frequently an open double block. On the other hand, men performed single and triple blocks more often than women, with open triple observed when serving from SA1. It is noticeable that most serves were executed from SA1. Men also hierarchically preferred to serve from SA6 and SA5, while women showed the opposite preference, which confirms the findings of previous studies (Barzouka et al., 2020, 2021; Kitsiou et al., 2020; Sotiropoulos, Drikos, Papadopoulou, et al., 2021; Stamm, Stamm, Vantsi, et al., 2016). Moreover, among the specialties of the players, male opposites (OPP) and outside hitters (OH1) were the ones that significantly contributed to the frequent formation of triple blocks compared to women, likely because of their frequent use of the PJS (Barzouka et al., 2021). As the PJS is known to reduce the reception performance of the opposing team, it helps the defending team's ability to form triple block (Ciuffarella et al., 2013).

This study is subject to several limitations. The sample, while substantial, is limited to 32 matches from a single tournament (2022 World Championships) and may not be fully representative of high-level volleyball played in other contexts or across different competitive levels. The reliance on a six-level tactical rating scale, while demonstrating acceptable reliability, introduces a degree of subjective assessment and may not capture the full complexity of serve and block interactions. Furthermore, the analysis focused solely on serve characteristics and block organization, neglecting other potentially influential factors such as player skill, tactical variations, and match context (e.g., score, game situation).

Conclusions

In conclusion, post-serve blocking strategies exhibited a gender-based dimorphism. Female athletes more frequently employed double and open double block formations, while male athletes demonstrated a higher incidence of single, triple, and open triple blocks. The serve type appears to be the primary determinant influencing block organization. Specifically, male outside hitters (OH) and opposites (OPP) generated greater reception difficulty compared to their female counterparts. This disparity is likely attributable to the prevalent use of the power jump serve (PJS) by male athletes, which subsequently created advantageous defensive opportunities, facilitating the increased formation of triple blocks within their teams.

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