


# Current trends of the serve skill in relation to the in-game roles of the elite volleyball players: Comparison between genders

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## ABSTRACT

The aim of this study was to investigate the current trends of the serve skill for each one of the in-game roles of the players for both genders in high-level volleyball. The serve actions of male (M) and female (F) elite players from 20 volleyball games (M = 10, F = 10) of the final phase World League 2018 were assessed. The analysed variables were comprised of the serve type, the serving area (SA), the serve direction, the in-game role of the server and the serve performance. Results showed that men mainly preferred the power jump serve from the areas behind zones 1 (SA1) and 6 (SA6), while they directed them to the back of the court and made more mistakes than women. Women preferred the floating jump serve directed to the left central part of the court. Regarding the in-game roles of the men, the receivers-attackers and the middle-attackers carried out their serves from SA1 and SA6 more frequently compared to women who preferred to use the serve area behind zone 5 (SA5) more frequently than men. Additionally, women opposites and setters chose to use the SA1 more frequently and the SA5 and SA6 less frequently in comparison to their men counterparts. **Keywords:** Volleyball; Serve; Performance indicators; Top-level; Correspondence analysis.

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## INTRODUCTION

In volleyball, the serve is a technical skill with which each rally of the game begins (Parisi & Raiola, 2014) and most of its types are determined through the athlete's posture before he/she hits the ball (Depra, Brenzikofer, Goes, & Barros, 1998). The serve is considered to be a preeminent offensive weapon for every team (Quiroga, Rodriguez-Ruiz, Sarmiento, Muchaga, Da Silva Grigoletto, & Garcia-Manso, 2012; Moras, et al., 2008) while it seems to have a purpose-determined nature and may be decisive in a team's performance (Drikos, Kountouris, Laios, & Laios, 2009) since it has become a means of directly winning a point or hindering the subsequent offensive action of the opponent team (Garcia-Tormo, Vaquera Jimenez, & Morante Rabago, 2015, p. 108). Moreover, it is the only action of the game preceded by a period during which the player has the chance to decide the serve-type, the trajectory of the ball and how much strength he/she will exert on it (Stamm, Stamm, Torilo, Thompson, & Jairus, 2016).

Five different types of serve are classified depending on the technique used when carried out (Costa, Afonso, Brant, & Mesquita, 2012). However, in the international-level volleyball, the frequency of using each one of the above-mentioned serve types seems to be different. According to Ciuffarella, Russo, Masedu, Valenti, & De Angelis (2013), only 3.3% of the serves which were carried out during the 28 games of the 2008-09 Men's World Championship were float serves without the jump. On the other hand, 26.9% of the total serves were jump float serves and 69.9% of them were power jump serves. The latter seemed to be used more often than the other serve types despite the fact that they showed relatively higher failure rates. This preference may be due to the fact that most of the successful jump serves were effective in increasing the difficulty of the opponent team reception, eliminating the possibility of a positive team attack (Ciuffarella et al., 2013). With regard to women, it was found that their main serve-type choice was the float serve (48.6%) while the rest of their serve-type choices were in a hierarchical order, the power jump serve and the jump float serve. Additionally, it is shown that the serve type was significantly related to the in-game role of the server (Quiroga, Garcia-Manso, Rodrigue-Ruiz, Sarmiento, De Saa, & Moreno, 2010). The aforementioned are in accordance with the study of Palao, Manzanares, & Ortega (2009) who found that during the 15th Mediterranean Games women used mostly the float serve while men used the power jump serves. Taking into consideration the above, it seems that distinguished differences exist between genders in the use of the serve types. Besides, it is notable that even youth female volleyball teams used float serve more frequently in comparison with the other serve types. On the contrary, youth male volleyball is characterized by a higher occurrence of powerful jump serves (Costa et al., 2012).

Apart from the gender preference for the type of serve used, a crucial factor that mainly concerns the tactics and is related to the individual characteristics and the subsequent actions of the players, is the area from which the serve is carried out (Quiroga et al., 2012). In women, the dominant serve area was found to be the SA1 which was chosen mainly by the setters, the opposites and most of the receivers-attackers (56.2%). The SA5 was chosen mainly by the middle-attackers (Maia & Mesquita, 2006; Quiroga et al., 2010; Quiroga et al., 2012). As far as men are concerned, it was found that the area from which the vast majority of their serves were carried out was SA1 while the serve type they opted for was the power jump serve. The next serve area in a hierarchical order was SA5 while the serve type used was mainly the jump float (Stamm et al. 2016).

At the high-level volleyball, one of the most important components in serve efficacy is the area where the serve is aimed to (Quiroga et al., 2012). Research studies indicated that a serve aimed near the side-lines and baseline (Moreno, Garcia de Alcaraz, Moreno, Molina, & Santos, 2007) increased the likelihood of the reception not going to an acceptable zone for the setting (Afonso, Esteves, Araujo, Thomas, & Mesquita, 2012). According to Ciuffarella et al. (2013), the areas where most of the serves were aimed were

hierarchically the zones 6, 7, 5, 1 and 8 (by 32.1%, 14.4%, 14.3%, 13.8% and by 13.7%, respectively). Furthermore, it is notable that a significant relationship has been observed between the serve effectiveness and the in-game role of the server. Indeed, Quiroga et al. (2010) reported that during two consecutive Final 4 of the Indesit European Champions League the female middle-attackers were the most effective servers since 56 of their 429 serves either led to scoring a direct point or limited the ability of the opposing team to mount the subsequent attack. On the other hand, the opposites showed the lowest service effectiveness since 16% of their serves were errors.

Taking all the above into consideration, as well as the evolution of volleyball, it is a common belief that the knowledge of the differences that distinguish the in-game roles of male and female players would be a useful tool for the coaches so that they can improve the effectiveness of the technical and tactical skills of their team. Therefore, the purpose of this study was to investigate the current trends of the serve skill for each one of the in-game roles of the players and to compare genders in high-level volleyball competitions.

## MATERIAL AND METHODS

### *Participants and procedures*

A three-member group of experienced coaches assessed 3507 serves that were carried out by male and female volleyball players (M = 1658, F = 1849) during 20 volleyball games (M = 10, F = 10) of National Teams competing in the final phase of World League 2018. Intra-rater and inter-rater reliability coefficients were found to be  $r = .983$  and  $r = .984$ , respectively, indicating very high consistency in the assessment procedure. The analysed variables comprised the serve type, the area from which the serve was carried out, the serve direction, the in-game role of the server and the degree of the serve performance.

### *Measures*

For the evaluation of the serve type, the proposal of Quiroga et al. (2010) was adopted. As such, five categories were established: a) the jump spin power serve (implies ball rotation, PJS), b) the jump float serve (without ball rotation, FJS), c) the overhead float serve (without ball rotation and jumping, FS), d) the overhead spin power serve (similar to the jump spin power serve but without jumping, PS) and e) the Asian float serve (serve without jumping, AFS). However, data analysis included only 3 of the 5 serve types since the 2 of them were not used by the players (PS and AFS).

The serving area, defined as the area from which the serve is carried out, covers a 9-metre wide space located behind the baseline of the court and as an extension to the side-lines, differentiates three areas of origin: a) the serving area 1 (SA1, behind zone 1), b) the serving area 6 (SA6, behind zone 6) and c) the serving area 5 (SA5, behind zone 5), as proposed by Fernandez-Echeverria, Gil, Moreno, Claver, & Moreno (2015).

For the evaluation of the serve direction, the defensive court was divided into 10 zones as proposed by Ciuffarella et al. (2013). However, data analysis did not include any serves that were assessed with performance score 0 (zone 10; 507 actions), since the ball was not directed into the court.

The in-game role of the server was defined as proposed by Alfonso et al. (2012) with the following categories: setter (S), attacker-receiver (A), middle-attacker (M) and opposite (O). For a more detailed definition of the in-game roles of the attacker-receivers and the middle-attackers, the latter were discriminated as attacker-receiver and the middle attacker who plays beside the setter (A1 and M1, respectively) and as attacker-receiver and the middle attacker who plays away from the setter (A2 and M2, respectively).

For the evaluation of the serve performance (SQG) the coaches were asked to observe and categorize the serve quality according to the effectiveness of the skill on a five-level ordinal tactical scale (Eom & Schutz, 1992) with the minimum value “zero” indicating a serve error and the maximum value “four” corresponding to a serve-ace (direct point).

### **Statistical analysis**

The test of independence for the categorical variables “gender” and “serve area” for each one of the 6 levels of variable “in-game role” was carried out using the Chi-square test ( $X^2$ ) and Fisher’s exact test (implemented with the statistical package SPSS v. 17). Following the overall independence test, we tested the difference in proportions between men and women, within each level of the “serve zone” variable for each one of the 6 “in-game roles” of the players (test of proportion differences based on the normal distribution) using the statistical package Statgraphics Plus v. 5.1. The same procedure was followed for the variables: “gender” and “serve type”, “gender” and “serve direction”, “gender” and “serve performance”. As a follow-up procedure, a Correspondence analysis was used in order to visualise the entries in the table of relative frequencies in terms of the distances between individual rows and columns in a low dimensional space. It was followed by the summarization of rows and columns coordinated in a biplot separately for each gender, and the interpretation of distances between row points (in-game role of players) and the distances between column points (serving area, direction, type and quality).

## **RESULTS**

### **Serve area choices of elite male and female players in relation to their in-game roles**

Men carried out 1658 serve actions, in total. Of these, 18% were performed by the A1, 15.9% by the A2, 14.8% by the M1, 17.9% by the M2, 17.2% by the O and 16.2% by the S. Women carried out 1849 serve actions, in total. Of these, 20.2% were performed by the A1, 15.9% by the A2, 14.7% by the M1, 16.3% by the M2, 16.9% by the O and 16.1% by the S. The statistical analysis showed a significant ( $p$ -value < .05,  $X^2$  Test) between genders and serve areas in each one of the 6 levels of the variable “in-game role” (Table 1). Moreover, after testing the difference in proportions of the serve area between genders, within each level of the “in-game role” variable it was found that a) males A1 carried out a statistically significantly higher proportion of serves from SA6 ( $p$ -value = .003) compared to females (16.4% vs 8.8%, respectively) while the latter carried out higher proportion from SA5 ( $p$ -value = .08) compared to males (35.8% vs 29.4%, respectively), b) males A2 carried out higher proportion of serves from SA1 and SA6 ( $p$ -value = .004 and  $p$  value = .03, respectively) compared to females (56.3 and 15.2% vs 44.2 and 9.2%, respectively) while females A2 carried out higher proportion from SA5 ( $p$  value < .001) compared to males (46.6% vs 28.5%, respectively), c) males M1 carried out higher proportion of serves from SA1 ( $p$  value < .001) compared to females (58.4% vs 4.1%, respectively) while the latter carried out higher proportion from SA5 ( $p$ -value < .001) compared to males (93.4% vs 39.2%, respectively), d) males M2 carried out higher proportion of serves from SA1 and SA6 ( $p$ -value < .001) compared to females (43.8 and 16.2% vs 4 and 0.3%, respectively) while females M2 carried out higher proportion from SA5 ( $p$ -value < .001) compared to males (95.7% vs 40.1%, respectively), e) males O carried out higher proportion of serves from SA5 and SA6 ( $p$  value < .001) compared to females (7 and 15.4% vs 1.6 and 1.3%, respectively) while females O carried out higher proportion from SA1 ( $p$ -value = .000) compared to males (97.1% vs 77.6%, respectively), f) males S carried out higher proportion of serves from SA5 and SA6 ( $p$ -value < .001) compared to females (30.6 and 19.8% vs 15.2 and 7.1%, respectively) while the latter carried out higher proportion from SA1 ( $p$ -value < .001) compared to males (77.8% vs 49.6%, respectively). In total, irrespective of the “in-game role” of the players, men carried out higher proportion of serves from SA1 and SA6 ( $p$ -value < .001) compared to women (56.6 and 14.5% vs 48.4

and 5%, respectively) while the latter carried out higher proportion from SA5 (p-value < .001) compared to their male counterparts (46.6% vs 29%, respectively).

Table 1. Serve area choices of elite male and female players in relation to their in-game roles.

Player role	Gender	Serve area (SA)			X <sup>2</sup> Value Sig.
		1 % (N)	5 % (N)	6 % (N)	
A1	Men	54.2% (162)	29.4% (88)	16.4% (49)	9.906 .007
	Women	55.3% (207)	35.8% (134)	8.8% (33)	
	Z	-0.28	-1.75	2.99	
	p <	ns	.08	.003	
A2	Men	56.3% (148)	28.5% (75)	15.2% (40)	20.157 .001
	Women	44.2% (130)	46.6% (137)	9.2% (27)	
	Z	2.85	-4.39	2.17	
	p <	.004	.001	.03	
M1	Men	58.4% (143)	39.2% (96)	2.4% (6)	183.002 .001
	Women	4.1% (11)	93.4% (253)	2.6% (7)	
	Z	13.5	-13.1	-0.14	
	p <	.001	.001	ns	
M2	Men	43.8% (130)	40.1% (119)	16.2% (48)	213.295 .001
	Women	4% (12)	95.7% (288)	0.3% (1)	
	Z	11.4	-14.6	7.09	
	p <	.001	.001	.001	
O	Men	77.6% (222)	7% (20)	15.4% (44)	53.802 .001
	Women	97.1% (303)	1.6% (5)	1.3% (4)	
	Z	-7.27	3.29	6.33	
	p <	.001	.001	.001	
S	Men	49.6% (133)	30.6% (82)	19.8% (53)	49.644 .001
	Women	77.8% (231)	15.2% (45)	7.1% (21)	
	Z	-6.99	4.38	4.46	
	p <	.001	.001	.001	

Men: N = 1658 (100%), Women: N = 1849 (100%).

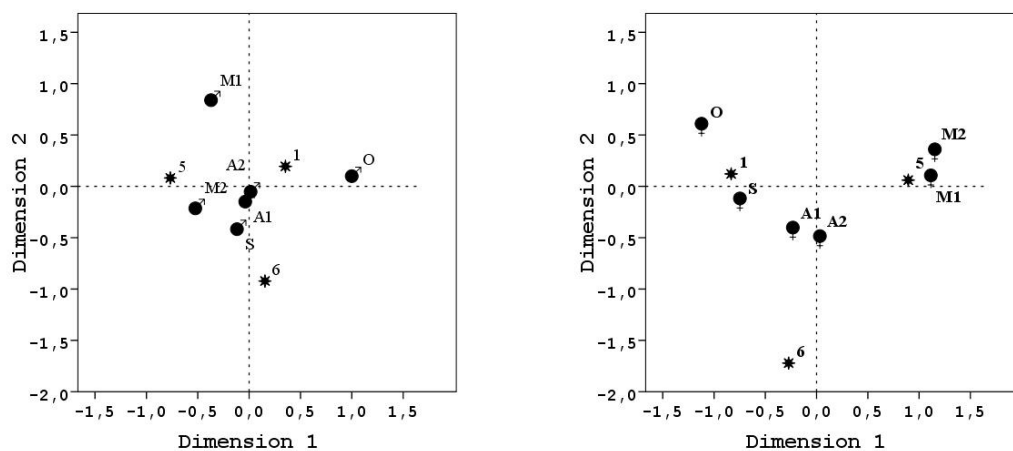


Figure 1. Correspondence analysis biplots for player's in-game roles and serve's area for men (left) and women (right).

Figure 1 presents the connectivity of in-game roles for female players with a specific serve area. Thus, M1 and M2 players serve from SA5, O and S serve from SA1, A1 and A2 prefer to serve from SA1 and SA5 than from SA6. Contrary to this, male players serve do not avoid serving from SA6 (except M1).

### Serve type choices of elite male and female players in relation to their in-game roles

Men carried out 1658 serve actions, in total. Of these, 75.4% were JS, 24.4% FJS and only 0.2% were FS. On the other hand, women carried out 1849 serve actions, in total. Of these, 4.9% were JS, 93.3% FJS and only 1.8% were FS. The statistical analysis showed a significant ( $p$ -value  $< .05$ ,  $X^2$  Test and Fisher's Exact Test) between genders and serve-type categories in each one of the 6 levels of the variable "in-game role" (Table 2). Moreover, after testing the difference in proportions of the serve type between genders, within each level of the "in-game role" variable it was found that a) males A1 carried out a statistically significantly higher proportion of PJS ( $p$ -value  $< .001$ ) compared to females (86% vs 0.3%, respectively) while the latter carried out higher proportion of FJS ( $p$ -value  $< .001$ ) compared to males (99.7% vs 14%, respectively), b) males A2 carried out higher proportion of PJS ( $p$ -value  $< .001$ ) compared to females (78.3% vs 4.8%, respectively) while females A2 carried out higher proportion of FJS ( $p$ -value  $< .001$ ) compared to males (95.2% vs 21.7%, respectively), c) females M1 carried out higher proportion of FJS ( $p$ -value  $< .001$ ) compared to males (100% vs 39.2%, respectively), d) females M2 carried out higher proportion of FJS and FS ( $p$ -value  $< .001$ ) compared to males (89 and 11% vs 41.4 and 0.3%, respectively), e) males O carried out higher proportion of PJS ( $p$ -value  $< .001$ ) compared to females (92.7% vs 24%, respectively) while the latter carried out higher proportion of FJS ( $p$  value  $< .001$ ) compared to males (76% vs 7.3%, respectively), f) males S carried out higher proportion of PJS ( $p$ -value  $< .001$ ) compared to females (74.6% vs 0.3%, respectively) while females S carried out higher proportion of FJS ( $p$ -value  $< .001$ ) compared to males (99.7% vs 24.6%, respectively). In total, irrespective of the "in-game role" of the players, men carried out higher proportion of PJS ( $p$ -value  $< .001$ ) compared to women (75.4% vs 4.9%, respectively) while the latter carried out higher proportion of JFS and FS ( $p$ -value  $< .001$ ) compared to their male counterparts (93.3 and 1.8% vs 24.4 and 0.2%, respectively).

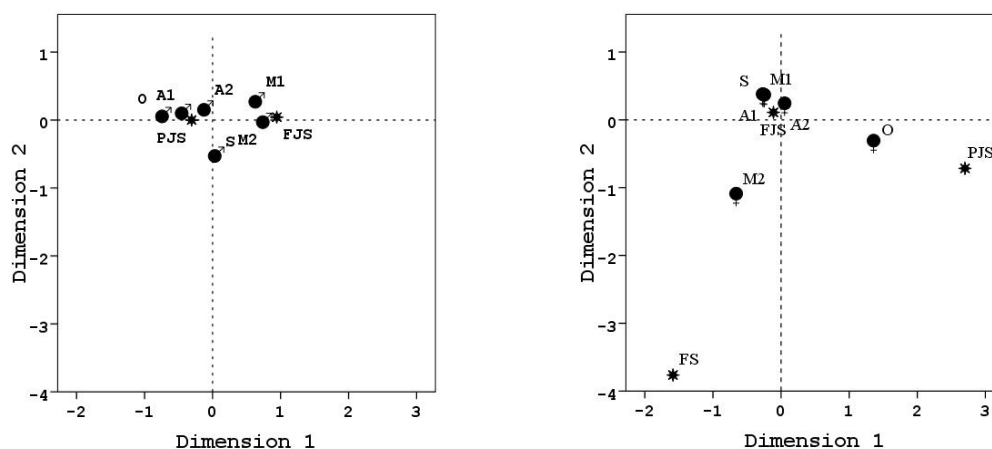


Figure 2. Correspondence analysis biplots for player's in-game roles and serve's type for men (left) and women (right).

Table 2. Serve type choices of elite male and female players in relation to their in-game roles.

Player role	Gender	Serve type			X <sup>2</sup> Value Sig.
		PJS % (N)	FJS % (N)	FS % (N)	
A1	Men	86% (257)	14% (42)	0% (0)	516.069
	Women	0.3% (1)	99.7% (373)	0% (0)	
	Z	22.7	-21.1		
	p <	.001	.001		
A2	Men	78.3% (206)	21.7% (57)	0% (0)	314.376
	Women	4.8% (14)	95.2% (280)	0% (0)	
	Z	17.7	-17.7		
	p <	.001	.001		
M1	Men	60.8% (149)	39.2% (96)	0% (0)	231.725
	Women	0% (0)	100% (271)	0% (0)	
	Z		-7.62		
	p <		.001		
M2	Men	58.2% (173)	41.4% (123)	0.3% (1)	256.875
	Women	0% (0)	89% (268)	11% (33)	
	Z		-12.2	-5.65	
	p <		.001	.001	
O	Men	92.7% (265)	7.3% (21)	0% (0)	286.425
	Women	24% (75)	76% (237)	0% (0)	
	Z	16.9	-16.9		
	p <	.001	.001		
S	Men	74.6% (200)	24.6% (66)	0.7% (2)	419.930*
	Women	0.3% (1)	99.7% (296)	0% (0)	
	Z	18.4	-18.6		
	p <	.001	.001		

\* Fisher's Exact test value, Men: N = 1658 (100%), Women: N = 1849 (100%), PJS: jump spin power serve, FJS: jump float serve, FS: overhead float serve.

The proximity of row and column labels is presented in Figure 2. Women players of all in-game roles use the FJS serving type and only opposite (O) players use PJS. Contrary to this, men players A1, A2 and O use PJS more than the other in-game roles (M1, M2, S).

### **Serve direction zones of elite male and female players in relation to their in-game roles**

Men carried out 1337 serve actions, in total. Of these, 75.4% were JS, 24.4% FJS and only 0.2% were FS. On the other hand, women carried out 1849 serve actions, in total. Of these, 4.9% were JS, 93.3% FJS and only 1.8% were FS. The statistical analysis showed a significant ( $p$ -value < .05, Fisher's Exact Test) between genders and serve direction zones in each one of the 6 levels of the variable "in-game role" (Table 3). Moreover, after testing the difference in proportions of the serve direction zone between genders, within each level of the "in-game role" variable, it was found that a) males A1 directed a statistically significantly higher proportion of serves into zones 1, 3 and 6 ( $p$ -value < .001,  $p$ -value = .01,  $p$ -value < .001, respectively) compared to females (17.6, 2.6 and 40.3% vs 6.4, 0.3 and 11.9%, respectively) while the latter directed higher proportion of serves ( $p$ -value < .001) into zones 7, 8 and 9 compared to males (35.4, 16.2 and 16.8% vs 9, 7.3 and 5.2%, respectively), b) males A2 directed higher proportion of serves into zones 5 and 6 ( $p$ -value < .001) compared to females (32.1 and 27.8% vs 9.1 and 18.1%, respectively) while the latter directed higher proportion of serves into zones 7 and 8 ( $p$ -value < .001) compared to males (31.3 and 21.1% vs 7.5 and 7.5%, respectively), c) males M1 directed higher proportion of serves into zones 5 and 6 ( $p$ -value < .001)

compared to their female counterparts (22.4 and 34.3% vs 12.7 and 15.2%, respectively). On the other hand, side female M1 directed higher proportion of serves into zone 7 (p-value < .001) compared to males (43.4% vs 15.4, respectively), d) males M2 directed higher proportion of serves into zone 5 (p-value < .001) compared to their female counterparts (24.7% vs 12.8%, respectively) while the latter directed higher proportion of serves into zone 7 (p-value < .001) compared to males (35.7% vs 19.8, respectively), e) males O directed higher proportion of serves into zones 1 and 6 (p-value < .001) compared to females (20.5 and 41.5% vs 8.1 and 18.9%, respectively) while the latter directed higher proportion of serves into zones 7, 8 and 9 (p-value < .001, p-value < .001 and p-value = .02, respectively) compared to males (20.4, 15.2 and 11.1% vs 7.6, 4.5 and 5.4%, respectively), f) males S directed higher proportion of serves into zones 1 and 6 (p-value < .001) compared to females (19.2 and 28.1% vs 7 and 9.2%, respectively) while the latter directed higher proportion of serves into zone 7 (p-value < .001) compared to males (35.5% vs 11.6%, respectively). In total, irrespective of the “in-game role” of the players, men directed higher proportion of serves into zones 1, 5 and 6 (p-value < .001) compared to their female counterparts (14.8, 21.8 and 32.1% vs 7.5, 15.1 and 14.6%, respectively). Contrary to this, women directed higher proportion of serves into zones 7, 8 and 9 (p-value < .001) compared to men (33.6, 15.9 and 12% vs 11.9, 9.3 and 8.3%, respectively).

Figure 3 explains that the point representing zone 2 is a highly discriminated attribute since it is the furthest from the origin for men (for women it does not exist in the biplot). For both genders, the setter player (S) served more often into areas of the offensive zone of the opponent’s court (zone 3 and 4 for men and zone 4 for women).

Table 3. Serve direction zones percentage of elite male and female players in relation to their in-game roles.

PR	Gender	Serve direction zones									Fisher's Test	
		1	2	3	4	5	6	7	8	9	Sig.	
A1	M	%	17.6	0	2.6	0.9	17.2	40.3	9	7.3	5.2	141.65
		(N)	(41)	(0)	(6)	(2)	(40)	(94)	(21)	(17)	(12)	
	W	%	6.4	0	0.3	0.3	12.8	11.9	35.4	16.2	16.8	.001
		(N)	(22)	(0)	(1)	(1)	(44)	(41)	(122)	(56)	(58)	
	Z	4.24	-	2.46	.96	1.47	7.92	-7.21	-3.16	-4.19		
	p <	.001	-	.01	ns	ns	.001	.001	.002	.001		
A2	M	%	12.7	1.4	0.5	0.0	32.1	27.8	7.5	7.5	10.4	93.631
		(N)	(27)	(3)	(1)	(0)	(68)	(59)	(16)	(16)	(22)	
	W	%	9.4	.0	0.4	0.4	9.1	18.1	31.3	21.1	10.2	.001
		(N)	(25)	(0)	(1)	(1)	(24)	(48)	(83)	(56)	(27)	
	Z	1.15		0.16	-	6.32	2.52	-6.37	-4.13	0.07		
	p <	ns		ns	-	.001	.01	.001	.001	ns		
M1	M	%	9.5	0	0.0	0.5	22.4	34.3	15.4	12.4	5.5	54.533
		(N)	(919)	(0)	(0)	(1)	(45)	(69)	(31)	(25)	(11)	
	W	%	8.2	0	0.4	1.2	12.7	15.2	43.4	12.3	6.6	.001
		(N)	(20)	(0)	(1)	(3)	(31)	(37)	(106)	(30)	(16)	
	Z	-0.48			-0.78	2.71	4.71	-6.37	-0.32	-0.48		
	p <	ns			ns	.007	.001	.001	ns	ns		
M2	M	%	9.1	0	0.8	0.4	24.7	21	19.8	13.6	10.7	29.827
		(N)	(22)	(0)	(2)	(1)	(60)	(51)	(48)	(33)	(26)	
	W	%	6.4	0	0.0	1.9	12.8	15	35.7	16.2	12	.001
		(N)	(17)	(0)	(0)	(5)	(34)	(40)	(95)	(43)	(32)	



		Z	1.14		-1.56	3.45	1.76	-3.98	-0.82	-0.46		
		p <	ns		ns	.001	ns	.001	ns	ns		
O	M	%	20.5	0.0	0.0	1.3	19.2	41.5	7.6	4.5	5.4	75.399
		(N)	(46)	(0)	(0)	(3)	(43)	(93)	(17)	(10)	(12)	
	W	%	8.1	0.7	1.5	0.4	23.7	18.9	20.4	15.2	11.1	.001
		(N)	(22)	(2)	(4)	(1)	(64)	(51)	(55)	(41)	(30)	
		Z	3.98		1.11	-1.21	5.50	-4.01	-3.887	-2.26		
		p <	.001		ns	ns	.001	.001	.001	.02		
S	M	%	19.2	1.3	0.0	1.3	15.6	28.1	11.6	10.3	12.5	81.613
		(N)	(43)	(3)	(0)	(3)	(35)	(63)	(26)	(23)	(28)	
	W	%	7	0.0	1.1	0.0	19.8	9.2	35.5	14.3	13.2	.001
		(N)	(19)	(0)	(3)	(0)	(54)	(25)	(97)	(39)	(36)	
		Z	4.09		-	-1.21	5.49	-6.14	-1.34	-0.23		
		p <	.001		-	ns	.001	.001	ns	ns		
Sum	M	%	14.8	0.4	5.7	0.7	21.8	32.1	11.9	9.3	8.3	
		(N)	(198)	(6)	(9)	(10)	(291)	(429)	(159)	(124)	(111)	
	W	%	7.5	0.1	2.8	0.6	15.1	14.6	33.6	15.9	12	
		(N)	(125)	(2)	(10)	(11)	(251)	(242)	(558)	(265)	(199)	
		Z	6.41	1.69	0.34	0.0	4.74	11.43	-13.8	-5.35	-3.31	
		p <	.001	ns	ns	ns	.001	.001	.001	.001	.001	

PR: player in-game role, M: Men, W: Women, N: Men = 1338 (100%), Women = 1663 (100%).

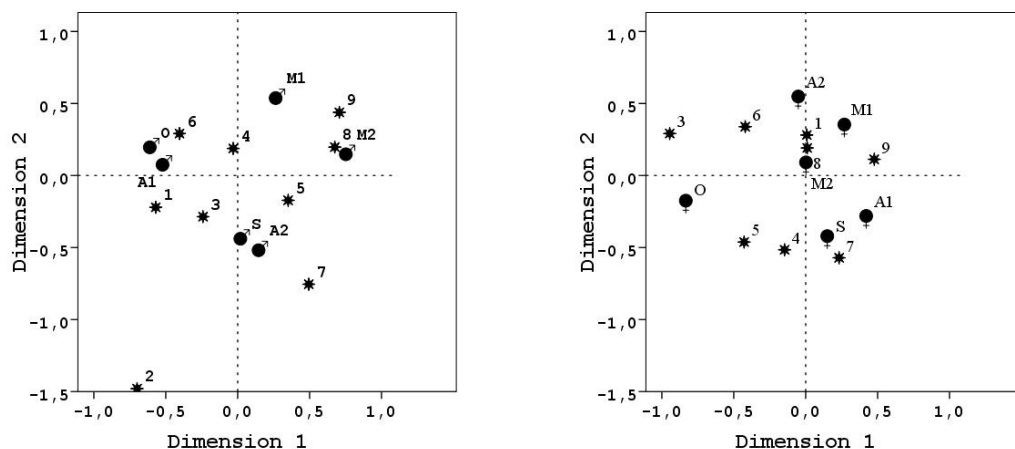


Figure 3. Correspondence analysis biplots for player's in-game roles and serve's direction for men (left) and women (right).

**Serve performance of elite male and female players in relation to their in-game roles**

Men carried out 1658 serve actions, in total. Of these, 19.4% were evaluated with SQG0, 21.2% with SQG1, 32.8% with SQG2, 20% with SQG3 and 6.6% were evaluated with SQG4. On the other hand, women carried out 1849 serve actions, in total. Of these, 10.1% were evaluated with SQG0, 27% with SQG1, 37.5% with SQG2, 19.9% with SQG3 and 5.5% were evaluated with the SQG4. The statistical analysis showed a significant relationship (p-value < .05, X<sup>2</sup> Test) between genders and serve performance in each one of the 6 levels of the variable "in-game role" (Table 4). Moreover, after testing the difference in proportions of the

serve performance between genders, within each level of the “*in-game role*” variable it was found that a) men A1 carried out a higher proportion of serves which were evaluated with SQG0 (p-value < .001) compared to women (22.1% vs 7.8%, respectively) while the latter carried out a higher proportion of serves which were evaluated with SQG1 (p-value = .001) compared to males (30.7% vs 19.7%, respectively), b) men A2 carried out a higher proportion of serves which were evaluated with SQG0 (p-value = .001) compared to women (19.4% vs 9.9%, respectively), c) men M1 carried out a higher proportion of serves which were evaluated with SQG0 (p-value = .008) compared to women (18% vs 10%, respectively), d) men M2 carried out a higher proportion of serves which were evaluated with SQG0 and SQG3 (p-value = .002 and p-value = .001, respectively) compared to women (18.2 and 21.2% vs 11.6 and 13.3%, respectively) while the latter carried out higher proportion of serves which were evaluated with the grade SQG1 (p-value = .003) compared to males (30.9% vs 22.9%, respectively), e) men O carried out a higher proportion of serves which were evaluated with SQG0 (p-value = .008) compared to women (21.7% vs 13.5%, respectively) while the latter carried out a higher proportion of serves which were evaluated with the SQG1 (p-value = .02) compared to males (23.7% vs 16.1%, respectively), f) men S carried out a higher proportion of serves which were evaluated with the SQG0 (p-value = .003) compared to women (16.1% vs 8.1%, respectively). In total, it was shown that SQG2 was the dominant value in serve performance for both genders. Moreover, irrespective of the “*in-game role*” of the players, men carried out higher proportion of serves which were evaluated with SQG0 (p-value < .001) compared to women (19.4% vs 10.1%, respectively) while the latter carried out a higher proportion of serves which were evaluated with SQG1 and SQG2 (p-value < .001 and p-value = .004, respectively) compared to males (21.2 and 32.8% vs 27 and 37.5%, respectively).

Table 4. Serve performance of elite male and female players in relation to their in-game roles.

Player role	Gender	Serve quality grade					X <sup>2</sup> Value Sig.
		0 % (N)	1 % (N)	2 % (N)	3 % (N)	4 % (N)	
A1	Men	22.1% (66)	19.7% (59)	33.8% (101)	16.7% (50)	7.7% (23)	35.786 .001
	Women	7.8% (29)	30.7% (115)	33.4% (125)	22.5% (84)	5.6% (21)	
	Z	5.29	-3.24	0.11	-1.87	1.09	
	p <	.001	.001	ns	.06	ns	
A2	Men	19.4% (51)	19.8% (52)	33.8% (89)	22.1% (58)	4.9% (13)	11.934 .016
	Women	9.9% (29)	23.8% (70)	40.8% (120)	20.1% (59)	5.4% (16)	
	Z	3.19	1.14	-1.70	0.58	-0.27	
	p <	.001	ns	.09	ns	ns	
M1	Men	18% (44)	21.6% (53)	34.3% (84)	18.4% (45)	7.8% (19)	9.927 .039
	Women	10% (27)	26.6% (72)	38% (103)	20.7% (56)	4.8% (13)	
	Z	2.63	-1.32	-0.87	-0.66	1.41	
	p <	.008	ns	ns	ns	ns	
M2	Men	18.2% (54)	22.9% (68)	33% (98)	21.2% (63)	4.7% (14)	15.305 .005
	Women	11.6% (35)	30.9% (93)	39.9% (120)	13.3% (40)	4.3% (13)	
	Z	2.27	-2.21	-1.75	2.56	0.24	
	p <	.02	.03	.08	.01	ns	
O	Men	21.7% (62)	16.1% (46)	30.1% (86)	22.7% (65)	9.4% (27)	14.641 .006
	Women	13.5% (42)	23.7% (74)	37.2% (116)	18.6% (58)	7.1% (22)	
	Z	2.64	-2.32	-1.83	1.24	1.02	
	p <	.008	.02	.07	ns	ns	

<b>S</b>	<b>Men</b>	16.1% (43)	27.7% (74)	32.3% (86)	19.1% (51)	4.9% (13)	10.580
	<b>Women</b>	8.1% (24)	25.3% (75)	37% (110)	23.9% (71)	5.7% (17)	.032
	<b>Z</b>	2.93	0.52	-1.17	-1.38	-0.42	
	<b>p &lt;</b>	.003	ns	ns	ns	ns	
<b>Sum</b>	<b>Men</b>	19.4% (320)	21.2% (352)	32.8% (544)	20% (332)	6.6% (109)	1658
	<b>Women</b>	10.1% (186)	27% (499)	37.5% (694)	19.9% (368)	5.5% (102)	1849
	<b>Z</b>	7.81	-4.00	-2.91	0.07	1.37	
	<b>p &lt;</b>	.001	.001	.004	ns	ns	

Serve quality grade: (0: error, 1: moderate, 2: good, 3: very good, 4: excellent, ace).

The proximity of row and column labels is presented in Figure 4. Male players with an in-game role as A1, M1, O, are more associated with aces and errors when serving than the other players (A2, M2, S), who are more conservative and associated more with moderate and good quality of serving. On the other hand, in female volleyball the opposite (O) player is connected with aces and errors when serving more highly than the other in-game roles. The other in-game roles of A1, A2, M1, M2, S are more conservative when serving.

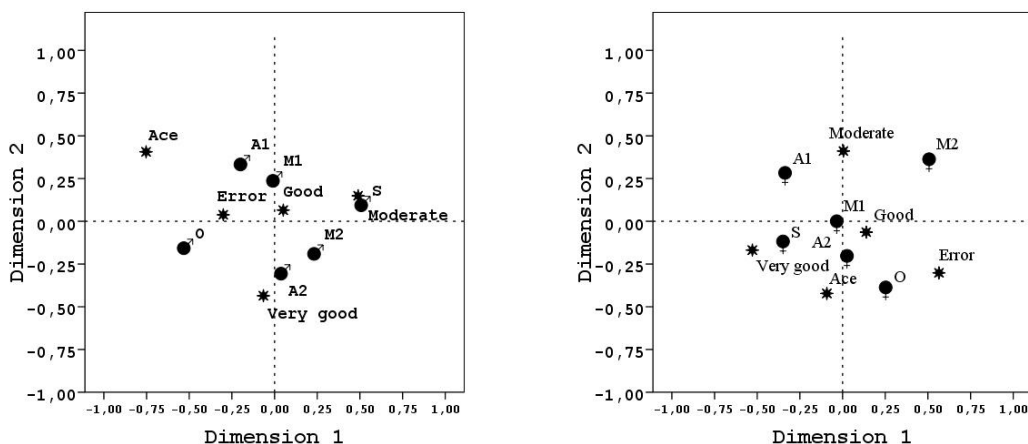


Figure 4. Correspondence analysis biplots for player's in-game roles and serve's quality for men (left) and women (right).

## DISCUSSION

One of the crucial findings of this study was that during the final phase of the 2018 World League, men used mainly the PJS, less the FJS and rarely the FS. On the other hand, women mainly used the FJS, less the PJS and seldom the FS. The above-mentioned differences between genders may be due to the fact that in equally trained men and women, men are stronger, heavier and taller and have better speed than female players (Bogdanovic, Vidakovic, Grbic, & Milic, 2014). Therefore, the use of techniques and their efficacy has been found to be different between genders (Palao, Manzanares, & Ortega, 2009) with men being able to apply quicker attack tempos (Afonso, Mesquita, & Palao, 2005; Castro & Mesquita, 2008; Palao, Santos, & Urena, 2004 a,b), stronger attacks (Costa, Caetano, Ferreira, Afonso, & Costa, 2011) and to use PJS in a more natural way than women (Costa et al. 2012).

The results of this study showed changes in the frequency and/or in the type of serve used in relation to the recent past. Indeed, although the serve type preferences of men remained the same compared to the

international standards of the previous decade, the frequency of carrying out the PJS showed an increase ranging from 4.4% to 5.5%. At the same time, the frequency of carrying out the FJS and the FS showed a decrease ranging from 0.6% to 2.5% and from 2.8% to 3.1%, respectively (Palao et al 2009; Ciuffarella et al. 2013). With regard to the serve efficiency, it was notable that most of the successful serve actions were carried out by the O and the A. Probably this may be due to their preference in PJS (92.7% and 86%, respectively) which is considered to make it difficult for the opponent to react and often creates favourable conditions for achieving a direct point (Ciuffarella et al. 2013). As far as women are concerned, although previous data show that the most frequently serve type used was the FS followed by the PJS and the FJS (Palao et al. 2009; Quiroga et al. 2010), this study showed that their main preference was the FJS which showed an increase ranging between 54 and 76.3%. Second in the order of women's preference remained the PJS, showing a reduction (19%) while in the last position was the FS which, compared to others, decreased by 46.2% - 46.8% (Palao et al. 2009; Quiroga et al. 2010). The current results are partially in line with the results of Inkinen, Hayrinen, & Linnamo (2013) who found that the dominant serve type used during the 2010 FIVB Women's Volleyball World Championships was the FJS (70.3%) while second and third in the ranking of the serve types used, were the FS and the PJS, respectively (19.2% and 10.5%, respectively). Taking into account the above, it is obvious that in high-level Women's Volleyball there is a rearrangement tendency of the serve types which are used by the players. Indeed, it is clear that the FJS has become the dominant serve type to the detriment of the use of the other types which as a result has noticeably decreased, with the FS being rarely used. Regarding the serve performance, most of the successful efforts were carried out by the O possibly because a crucial percentage of their total serves were PJS (24%) which are considered to be the most effective (Ciuffarella et al. 2013).

Apart from the preference of the genders as to the type of the serve used, another parameter that mainly concerns its tactics and is related to the individual characteristics of the athletes and their subsequent actions is the area from which it is carried out (Quiroga et al., 2012). The current study showed that both men and women preferred to carry out their serves mostly from the SA1 and less frequently from the SA6 confirming previous relevant studies (Quiroga et al. 2012; Stamm et al. 2016). Men, however, used SA1 and SA6 more often than women, while SA5 less often, probably because of the kind of the serve they chose (PJS vs FJS, respectively). Taking into account the in-game roles of the players, it was found that male A2, M1 and M2 carried out their serves from SA1 more frequently compared to their female counterparts. On the other hand, SA1 was used by the women O and S more frequently in comparison to men. This reinforces the findings of previous studies stating that volleyball female athletes use the serve area which facilitates the shorter transition to the space that the team's defence system requires to cover (Maia & Mesquita, 2006; Mesquita, Manso, & Palao, 2007) However, according to the results of this research, this did not appear to be the case for men who chose to carry out their serves more frequently from SA1 and SA6 compared to women. This was probably due to the fact that these areas served the execution of the most frequently used type of serve, which for men was the PJS.

As regards to the serve direction in relation to the gender and the in-game roles of the players, the results showed that men directed their serve mainly at the back of the court and hierarchically in zones 6, 5 and 1. This may be due to the fact that most of the men's serves were PJS, which because of the height of the net and the distance from the execution point were directed mainly to the central and the back part of the court (Ciuffarella et al. 2013). However, regardless of the serve type it appeared that the serves which were directed to zone 5 were a lot more than the ones which were directed to zone 1, perhaps because of the effort of the players to create difficult conditions in the reception and therefore in the attack of the opponent A of the front court. As for women, it was found that regardless of their in-game role, most serves were directed to the middle part of the court and mainly to zone 7 probably because of their intention to harden the

reception and then the attack of the opponent A of the front court. However, it was notable that the O directed their serves mainly (42.6%) to the back part of the court perhaps because of their choices to perform mainly PJS and FJS.

Concerning the serve performance in terms of gender and the in-game roles of the players, it was found that the majority of the serves of both men and women were evaluated with the SQG2 as they made it difficult for the S of the opposing team to organize the game. Hierarchically, the next lower proportion of the serves of both genders was evaluated with the SQG1 as they made it easy for the opponent S to organize the offense of his/her team. Regarding men, however, the most efficient performance was presented hierarchically by the O, the M2 and the A1. Most of the errors were made hierarchically by the A1 and the O, probably due to the execution of a larger number of attempts and PJS compared to their counterparts.

Regarding women, the most efficient performance was presented hierarchically by the O, the S and the A1. Concerning the O, the explanation probably lies in the higher proportion of PJS executed by them in comparison to their counterparts. Besides, it is known that PJS is more effective than the other serve types (Palao et al. 2009). However, it is notable that when the serves which were evaluated with both SQG4 and SQG3 were taken into account, the most efficient performance was presented hierarchically by the S, the A1 and the O (29.6%, 28.1% and 25.6%, respectively). This contradicts the results of Quiroga et al. (2010) who found that the most effective female servers were the M and the A (13.1% and 10%, respectively). This discrepancy may be due to the chosen serve type and/or the serve area observed in the current study which seems to be quite different compared to the recent past. Indeed, according to this study the proportion of the FJS carried out by the players, irrespective of their in-game role, was increased by 76.3% while the proportion of PJS and FS was diminished by 19% and 46.8%, respectively. In particular, the proportion of FJS carried out by the S was increased by 90.6% whereas the proportion of PJS and FS was diminished by 14.5 and 56.5%, respectively. This change may be a key factor since FJS is found to be the most effective type of serve while the FS the least effective one (Garcia Tormo et al., 2015). Besides, in women's volleyball, the FJS is the serve which achieves the highest efficacy rate, making reception difficult and minimizing the attacking options of the opponent team (Palao et al. 2009). On the other hand, the PJS is considered to be a very effective serve type but it involves a high risk of error (Palao et al., 2009; Garcia Tormo et al., 2015). As regards to the middle-attackers Quiroga et al. (2010) reported that during the Final 4 of the 2004 and 2005 Indesit European Champions League, 54.1% of the serves were carried out from the SA5, 30.3% from the SA1 and 15.6% from the SA6. On the contrary, the current study found that the vast majority of their serves were carried out from the SA5 (94.6%) probably because of their intention to facilitate the transition from the serve area to the defence zone by reducing the distance they had to cover, while complying with the defence system of their team (Maia & Mesquita, 2006; Mesquita et al., 2007). However, this was possibly a crucial parameter for the decrement of the SQG of the M since their choice to carry out mainly one serve type from mostly the same SA may have created favourable conditions for the organization of the subsequent offence of the opponent team.

## CONCLUSIONS

Overall, male volleyball players, regardless of their in-game role, mainly preferred the PJS, the SA1 and SA6 for the execution of their serves while they directed them to the back of the court and made more mistakes than female. Females preferred the FJS, the SA1 and SA5 for the execution of their efforts while they directed their serves to the left central part of the court. Moreover, they created more often ideal conditions for the opponent S in the organization of the game compared to men. Taking into account the individual in-game roles, males M2 impeded the attack organization of the opposing team more often than the respective women

athlete. Among both males and females, the O was he/she who presented the highest proportion of serve effectiveness as well as the most errors probably due to the use of the PJS. In the future it is proposed that a similar study should be carried out taking into consideration different game and age levels.

## AUTHOR CONTRIBUTIONS

Karolina Barzouka was the Primary author conceived the ideas or experimental design of the study and wrote most of the paper, Konstantinos Sotiropoulos conceived the ideas or experimental design of the study and provided revisions to scientific content of manuscript, Sotirios Drikos was responsible for data analysis and interpretation and provided revisions to scientific content of manuscript, Andriana Kitsiou performed data collection and Yannis Angelonidis provided access to crucial research components and provided stylistic/grammatical revisions to manuscript.

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## DISCLOSURE STATEMENT

The authors declare no conflicts of interest.

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