Sports Science

Variations in attack patterns and effectiveness between female and male middle players in top-level volleyball

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Abstract - Aim: This study aims to analyze the associations between variables that predict the attack effectiveness of middle players (MPs) in top-level volleyball, recognizing their significant influence on the team's offence under mostly optimal conditions while considering potential gender differences. **Methods:** Inferential statistics, multinomial logistic regression and multiple correspondence analysis were applied to analyze 843 attacks (508 for women and 335 for men) from the six top-ranked teams in the Men and Women World Championships 2018. **Results:** The analysis revealed that the two genders vary in some aspects of the game at the top level. Women MPs attack mainly from the area behind the setter, even after a good pass, against a team block but with lower attack effectiveness than men MPs who use to attack mainly in front of the setter, after an accurate pass against a single block. The attack effectiveness for both genders depends highly on the setting quality. **Conclusion:** In female volleyball, to increase effectiveness libero player is preferable to execute the first touch of the ball and MP to avoid off-speed attacks and to upgrade the effectiveness of spikes to zone 5 of the opponent court, while in male volleyball the existence of three attackers in the front row increases the odds for a winning attack.

Keywords: performance analysis, gender, multinomial logistic regression, in-game roles.

Introduction

In volleyball, the rule that requires players to rotate through all positions on the court, created the conditions for the specialization of the players depending on specific motor tasks/ skills that have been assigned to them. Thereafter, due to the constantly emerging tactical demands, the in-game functions of the players were divided into five (5) in-game roles, referred to as: setter (S), outside hitter (OH), opposite (Opp), middle player (MP) and libero (LBR)[1]. As a consequence of the regulation included the libero as a defensive player, the function of the MPs is limited mostly to the front row, mainly block and attack[2]. MPs play in the centre of the net during their front-row positions usually performing first-tempo attacks[3]. The use of the first tempo increase the occurrence of a single block and no block situations[4] and provoke a higher uncertainty in the opposing team, resulting in a higher likelihood of success for the offence[5]. Generally, MPs do not touch the ball during offence unless the pass to the setter is fairly accurate. So MPs are involved in the team's offence under optimal conditions with an expectation of a positive outcome[3,6]. Of all the skills in the game (serve, pass, block, defence, attack), the attack is the one that has the highest correlation with success, regardless of the complex of the game[7], the level of players[8], and the gender[9,10]. A notable distinction exists between male and female volleyball matches, specifically regarding game speed. Empirical evidence suggests that male players exhibit higher serve speeds[11] and a greater propensity for fast-tempo attacks than their female counterparts[12,13]. This disparity in playing style directly translates to shorter rally durations in men's matches[14], indicative of a faster-paced and more dynamic game. MPs greatly influence their team's offensive game for both genders compared with the other in-game role attackers (outside hitters and opposites)[15,16]. Furthermore, both genders commonly employ the MP as a strategic threat to disrupt the opponents' block and defensive schemes[17,18]. In a systematic review of MPs Millan-Sanchez et al.[19] concluded that MPs lead their teams in terms of physical attributes overall: body height, reach, and spike reach which could be explained by the lowest Body Mass Index (BMI) values shown. Despite the similarities between the two genders in the relationship between the MPs and the other players' specializations, there are significant differences in the game's attributes between genders, as independent of the in-game role of the players and the complex of the game, men attack in a fas-

ter tempo[13], with higher risk[20] and greater effectiveness using stronger spikes[21], compared to women, exploiting the higher absolute muscular strength of the lower and the upper body part[22].

Despite established evidence of the critical role of MPs in volleyball[19] and documented gender-specific differences in their game functions[13,21,22,10,20], a comprehensive understanding of how technical actions and offensive performance vary between male and female MBs remains elusive. This study hypothesized a significant gender-based difference in the impact of passing and setting quality, spatiotemporal characteristics of offensive actions, and opponents' block type on attack efficacy. Therefore, this study aimed to analyze the associations between passing and setting quality, spatiotemporal characteristics of offensive actions and opponents' block type in terms of each one of the game complexes, in addition to revealing how these affect the performance of the MP concerning attack efficacy for both genders in top-level volleyball.

Methods

Sample

A systematic observation[23] was applied for the data collection. Twenty matches, 10 for men (37 sets) and 10 for women (42 sets) of the six top-ranked teams in the third and the final phase of Men and Women 2018 World Championship were analyzed. Matches from the third and the final stage were chosen to ensure the high level of the teams. The selected sample represented twelve national teams. The analysis embraced 843 attacks from the MPs (508 attacks for women and 335 for men). The dependent variables considered in this research were the gender of the MPs and the quality of the attack. This research complies with the Local Ethic Committee.

Variables

For the identification and selection of independent variables and to represent important aspects of attack performance for the middle attacker, the independent variables in this study were in line with previous research in volleyball[19]:

1) Complex of the game (C). The categories are complex (CI) defined as the situation when the team performs the actions of pass after the opponent's serve, setting and attack, Complex II (CII), defined as the situation when the team performs the actions of serve, block, defence, setting and counter-attack in sequential order[24].
2) Pass position (PP) is defined as the area of the court where the ball was set to the attacker. The categories were: positions 1, 6, 5, 4, 3, and 2 (z1-z6) according to the court diagram.
3) In-game role of the passer (RP), defined as the in-game role of the passer according to the team's line-up categorized as outside hitter (OH), libero (LBR) or another player (Other).
4) Pass Quality (PQ), is defined as the effect obtained during the previous pass (serve reception, free ball, or dig) before setting for the attack. For the evaluation of the grade of the pass quality, a 5-level tactical rating scale proposed by Eom and Schutz[25] was used. The levels of the scale were labelled as error (E), moderate (M), good (G), very good (VG) and perfect (P). Passes evaluated as errors did not record as no attack followed.
5) Setter's position (SP) is defined as front row (FR) when the team is in rotations R4, R3, R2 and back row (BR) when the team is in rotations R1, R6, R5.
6) Setting type (ST), is defined as the type of setting for the middle attacker concerning the distance from the setter[3]. All sets are assumed to have originated from the setter's position (Figure 1). The categorization of the spatiotemporal characteristics of the setting type was according to the analysis of Afonso et al.[26] for the tempo of setting and Fellingham et al.[27] for the zone of setting. As 11 categorized 1st tempo sets directly in front of the setter, as 21 categorized 1st tempo sets 1,5-2 m. in front of the setter and as 31 categorized sets approximately 3 m. from the setter and the left sideline. About backward sets, as A1 categorized 1st tempo sets directly behind the setter, as B1 categorized 1st tempo sets 1,5-2 m. behind the setter and as B2 categorized sets on the right sideline.
7) Setting quality (SQ) was defined as the effect of the setting's accuracy in relation to attacker and the condition of opponent block against the attacker. For the evaluation of the grade of the quality of the setting, a 5-level tactical rating scale was used[25,28]. The levels of the entire evaluation scale were moderate error (E), (M), good (G), very good (VG) and perfect (P). Settings evaluated as errors did not record as no attack followed.

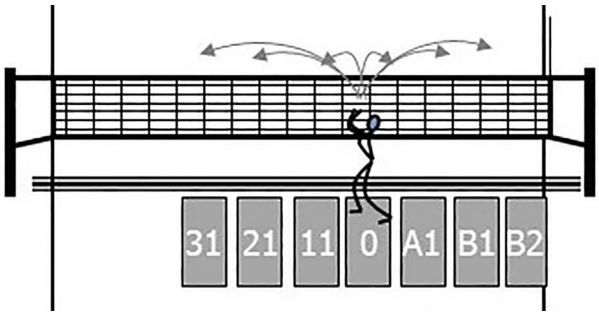

Figure 1 - The origin and the destination of the sets under consideration relative to the distance from the setter along the net.

8) Attack type (AT) is defined as the technical criteria related to the attack. The categorization proposed by Costa et al.[29] was a strong attack (SA), and an off-speed attack (OFA) performed with less force (roll shot or tip).
9) Attack direction (AD) is defined as the area of the court where the ball was directed by the attacker. The categories were: zones 1, 6, 5, 4, 3, and 2 (Z1-Z6) according to the court diagram.
10) Attack Quality (AQ). The FIVB system criteria were used, as in preceding studies[30]. According to this system, differentiation was made between win attack (W) which resulted in a winning point for the offensive team, lost attack (L) which resulted in a lost point for the offensive team (attack out of the bounds, on the net or attack stuffed by opponent's block and neutral attack (N), which resulted in the continuation of the action with the ball to the offensive or defensive team.
11) Block type of the opponent (BT), defined as the number of players who participated in a block. Categories were single block (S) conducted by one player, team block (T) composed by two or three players, and no block (NB) when no one blocked the attacker.

Data collection and procedures

The recording and entry of the data were done as follows: all the matches were analyzed by two experienced and trained observers. The reliability of the observations was assured by the inter-observer and intra-observer agreement within a 15-day interval. Ten per cent (10%) of the total observations were analyzed, according to the minimum threshold provided in the literature[31]. Inter-rater and intra-rater reliability coefficients were estimated using Cohen's kappa coefficient. The coefficient was 0.844 for inter-rater and 0.91 for intra-rater reliability, indicating an acceptable index (greater than 0.8) according to the literature[32].

Statistical analysis

The objective of the analysis was to determine i) which variables were significantly differentiated between genders for a MP and ii) which variables were significantly associated with attack quality for MPs for each gender. Initially, the descriptive analysis of the variables was performed to discover the frequencies of each variable under study. Afterwards, inferential analyses were conducted to examine the relationships between i) the studied variables and the gender and ii) the studied variables and the attack quality per gender. These analyses are conducted through contingency tables including Chi-square and Cramer's V and standardized residuals for each cell in the design. The statistical significance level considered was $p < 0.05$, while Cramer's V interpenetration according to Cohen[33] guidelines was: > 0.05 weak, > 0.1 moderate, > 0.15 strong, > 0.25 very strong association. Standardized residuals beyond the range of ± 2 (by convention instead of 1.96) mean that the specific cell is a major (if it is > 2) or a weak contributor (if it is < 2) to the overall chi-square value. Two-way contingency tables were graphically displayed using mosaic plots to determine which combinations of the variables' categories were the most responsible for the association when the null hypothesis of independence was rejected. In this kind of plot, the width and height of the tiles show the relative frequencies of the variables under consideration. Color coding and edges drawing for the mosaic tiles correspond to the absolute size and sign of each cell residual. Moreover, fixed cutoffs of ± 2, and ± 4 are used to shade cells that are individually significant at approximately $a = 0.05$ and $a = 0.001$ levels, respectively. All of the previously mentioned characteristics of mosaic plots allow to visually assess the structure of the association between variables.

Furthermore, a multinomial logistic regression was applied to construct models, one for each gender that could determine which of the independent variables is more relevant to the attack quality of a MP in top-level volleyball. The use of this regression model allows obtaining the regression coefficients reflecting the changes in the explanatory variable (dependent variable) due to the independent variables. The Odds Ratios (OR) and their 95% confidence intervals (C.I.) were calculated.

Finally, multiple correspondence analyses (MCA) to represent graphically the information contained in the multiway contingency tables were carried out on skills' data for i) both genders and ii) for attack quality per gender. The statistical instruments used were IBM SPSS Statistics for Windows and statistical significance was set at $p < 0.05$ and the programming software R with the development environment R studio using the library *vcd* for the analysis of two-way consistency tables.

Results

Inferential analysis for genders

The frequencies of reported data of independent variables as well as Chi-square analyses are presented in Table 1 and Table 2.

There was a significant relationship between the gender and the following independent variables: pass position (PP), pass quality (PQ), setter's position (SP), setting type (ST), attack direction (AD), attack quality (AQ) and block type (BT). The variable ST is characterized by a very strong association with gender, the variables AD and BT are characterized by a strong association with gender, while the variables PP, PQ, and AQ are characterized by a moderate association with gender. The structure of the relationships is revealed by mosaic plots (Figure 2).

Table 1 - Descriptive data concerning variables under analysis.

Variable	Category	Attack quality (observed counts %)							
		Female				Male			
		L	N	W	Total	L	N	W	Total
Complex	C I	14.2	35.9	49.9	78.9	12.9	27.1	60.0	76.1
	C II	9.3	43.9	46.7	21.1	11.3	26.3	62.5	23.9
Pass position	z1	13.6	38.8	47.6	20.3	17.2	31.3	51.6	19.1
	z2	12.5	50.0	37.5	3.1	9.1	18.2	72.7	3.3
	z3	12.5	50.0	37.5	3.1	4.3	26.1	69.6	6.9
	z4	14.3	42.9	42.9	1.4	0.0	16.7	83.3	3.6
	z5	15.7	37.3	47.0	36.4	3.3	17.4	70.7	27.5
	z6	10.5	34.8	54.7	35.6	5.4	33.1	53.4	39.7
In-game role of passer	OH	11.8	38.4	49.8	65.2	12.0	28.2	59.8	62.4
	L	18.7	27.6	53.7	26.4	15.3	23.5	61.2	25.4
	Other	7.0	62.8	30.2	8.5	9.8	26.8	63.4	12.2
Pass quality	M	0.0	33.3	66.7	1.2	0.0	42.9	57.1	2.1
	G	20.2	41.7	38.1	16.5	18.5	44.4	37.0	8.1
	VG	8.5	37.7	53.8	25.6	13.6	23.7	62.7	35.2
	P	13.5	36.5	50.0	56.7	11.5	25.7	62.8	54.6
Setter's position	FR	10.2	38.2	51.6	50.0	7.7	30.8	61.5	42.7
	BR	16.1	37.0	46.9	50.0	16.1	24.0	59.9	57.3
Setting type	11	18.2	41.6	40.3	15.2	13.8	13.4	56.6	45.4
	21	10.0	45.0	45.0	3.9	13.8	3.6	67.7	19.4
	31	13.4	35.3	51.3	36.8	10.3	7.8	62.9	29.0
	A1	14.3	35.7	50.0	2.8	11.1	1.8	55.6	5.4
	B1	9.4	28.1	62.5	6.3	0.0	0.0	100.0	0.3
	B2	11.8	39.3	48.9	35.0	0.0	0.3	50.0	0.6
Setting quality	M	50.0	25.0	25.0	0.8	50.0	50.0	0.0	0.6
	G	24.3	67.6	8.1	7.3	33.3	44.4	22.2	8.1
	VG	20.1	58.2	21.6	26.4	19.8	50.5	29.7	27.2
	P	8.7	26.1	65.2	65.6	6.5	14.4	79.1	64.2
Attack type	SA	14.1	29.8	56.1	80.7	12.1	21.6	66.3	84.2
	OFA	9.2	70.4	20.4	19.3	15.1	54.7	30.2	15.8
Attack direction	Z1	13.1	31.0	55.9	28.5	7.1	24.3	68.6	20.9
	Z2	8.0	36.0	56.0	4.9	0.0	27.3	72.7	3.3
	Z3	10.5	55.3	34.2	7.5	21.7	52.2	26.1	6.9
	Z4	12.0	56.0	32.0	4.9	20.0	60.0	20.0	1.5
	Z5	18.4	31.2	50.4	27.8	12.0	18.8	69.2	39.7
	Z6	9.7	43.3	47.0	26.4	16.1	32.3	51.6	27.8
Block type of opponent	S	13.9	35.9	50.2	49.4	11.7	25.4	62.9	71.6
	T	13.4	39.3	47.3	47.0	17.1	31.7	51.2	24.5
	NB	0.0	38.9	61.1	3.5	0.0	23.1	76.9	3.9
Total		13.2	37.6	49.2		12.5	26.9	60.6	

Table 2 - Relationships between independent variables and the dependent variable (gender).

Variable	X^2	p	Cramer's V††
Complex	0.928	0.335	0.033
Pass position	**16.353**	**0.006**	**0.139**
In-game role of passer	3.206	0.201	0.062
Pass quality	**18.617**	**<0.001**	**0.149**
Setter's position	**4.334**	**0.037**	**0.072**
Setting type	**253.804**	**<0.001**	**0.549**
Setting Quality	0.368	0.947	0.021
Attack type	1.654	0.198	0.044
Attack direction	**21.678**	**0.001**	**0.160**
Attack quality	**11.912**	**0.003**	**0.119**
Block type of opponent	**44.200**	**<0.001**	**0.229**

††Cramer's V: > 0.05 weak, > 0.1 moderate, > 0.15 strong, > 0.25 very strong association.
All significant relationships are presented in bold.

Figure 3 displays the two-dimensional map resulting from the multiple correspondence analysis applied to the multiway contingency table of attack data per gender the first two dimensions, namely those represented in the map, accounted for 44.03% of the total variance. The first (horizontal) dimension explaining 25.37% of the total variance may be considered to reflect the trend of gender characteristics concerning the patterns of middle attack. The male gender connects with perfect (P) or very good (VG) passes, win attacks 11 and 21 types, against a single block (S). Contrary, the female gender connects with a good pass (G), attack B1 and B2, with the setter in the front row (FR), against team block (T) and continuation of the rally (N). The second dimension (vertical, 18.66% of the explained variance) may instead reflect the connection of PQ with AQ, such as moderate (M) and good (G) passes to connect with neutral (N) and lost (L) attacks, while very good (VG) and perfect (P) passes to connect with win attacks (W).

Inferential analysis for attack quality per gender

Table 3 summarizes the chi-square analyses concerning the attack quality per gender.

In the male category, there was a significant relationship between AQ and the following independent variables: SP, SQ, AT, and AD. The variables SQ and AD are characterized by a very strong association with AQ, the variable AD by strong association, while SP is characterized by a moderate association with AQ. There was no significant relationship between AQ and C, PP, RP, PQ, ST, and BT. So, these variables could not be included in the multinomial logistic regression model.

In the female category, there was a significant relationship between AQ and the variables: RP, SQ, AT, and AD. The variables SQ and AT are characterized by

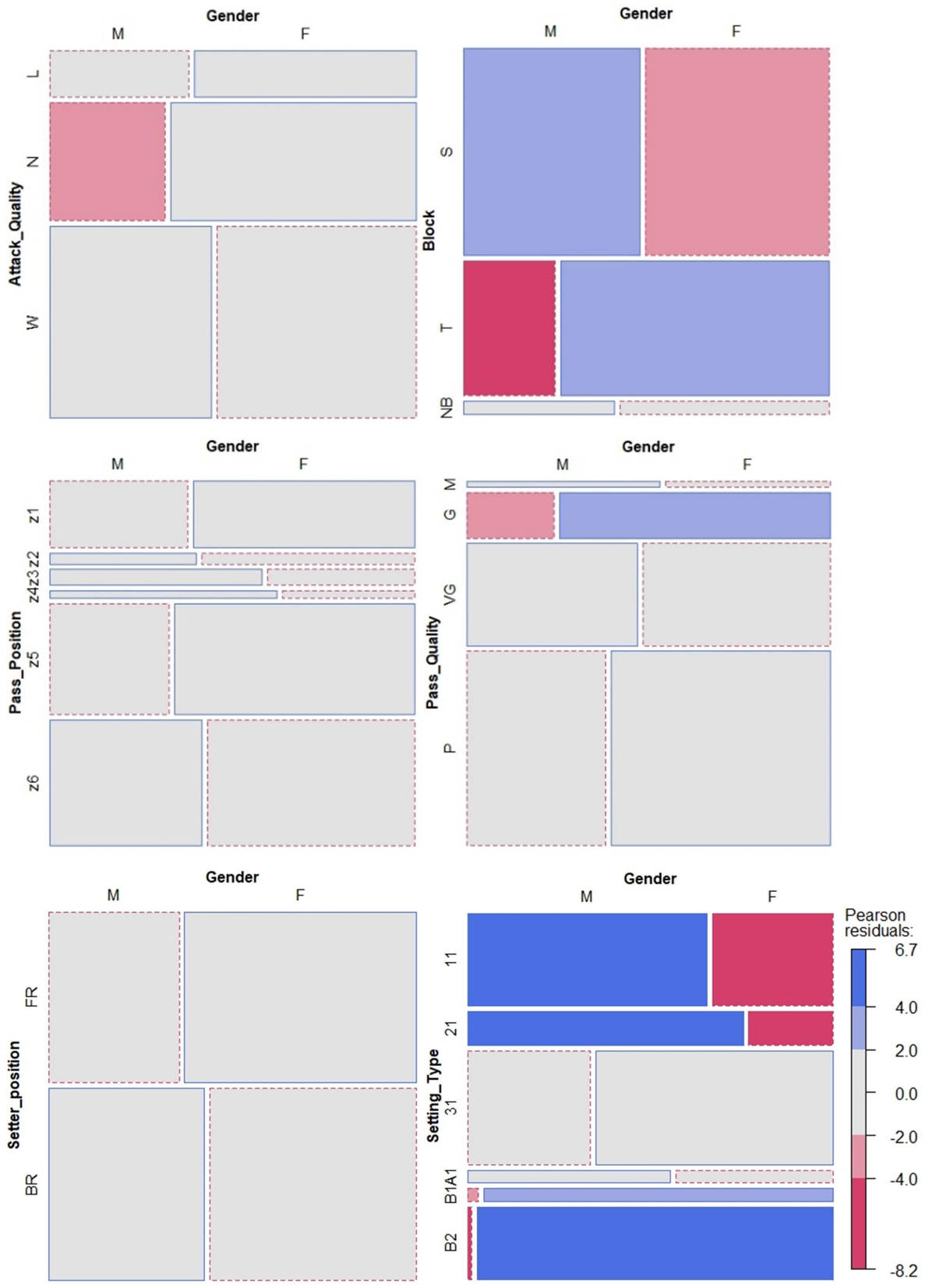

Figure 2 - Mosaic plots of the two-way contingency tables of attack patterns per gender. For each cell, the standardized Pearson residuals are indicated using different cell shadings and edges (dash lines for negative values and continuous lines for positive values).

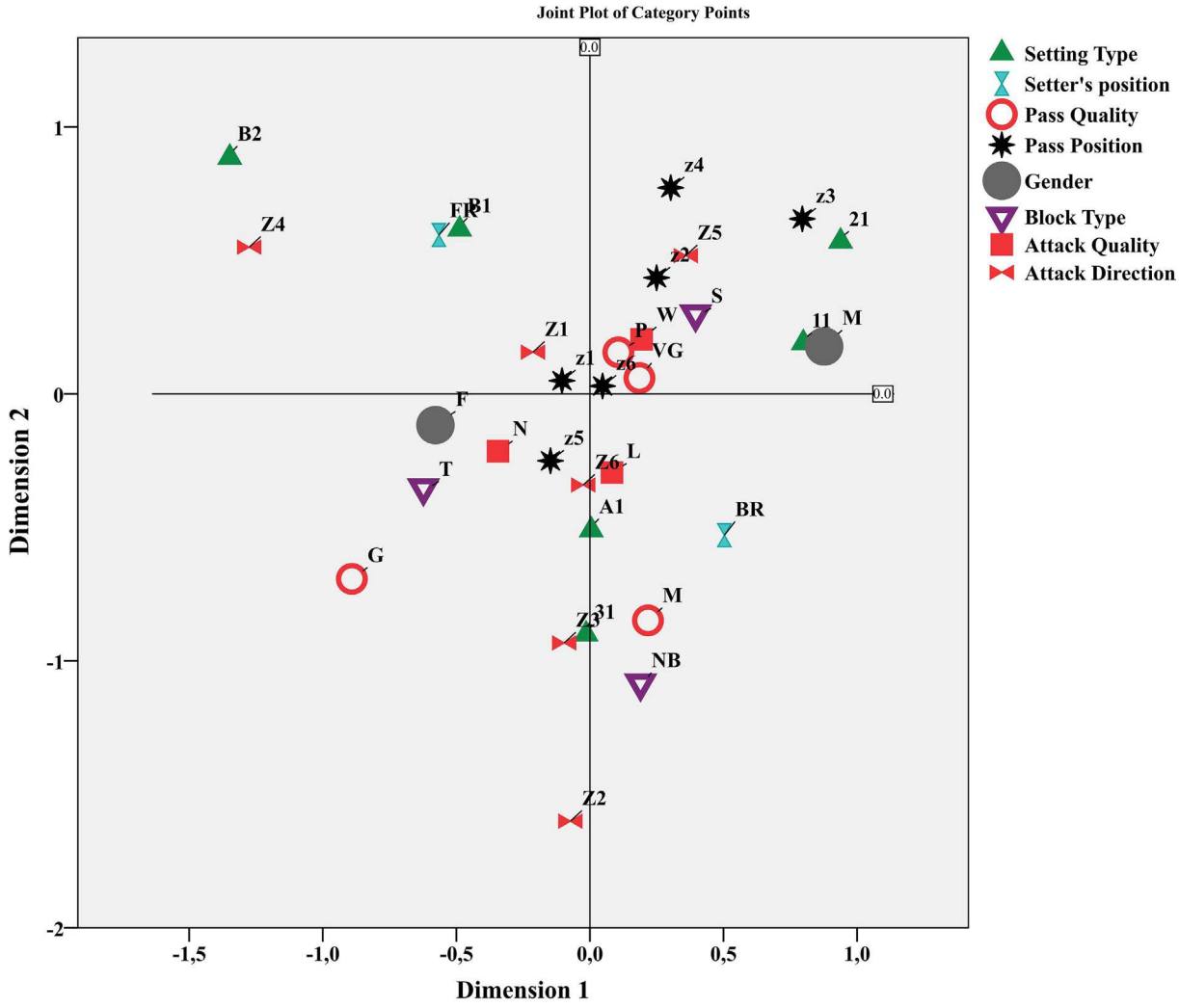

Figure 3 - Map obtained by the multiple correspondence analysis performed on the contingency table formed by setting type, setter position, pass quality and position, gender, attack direction and quality, and block type. The map displays the coordinates of categories of all variables in the two dimensions that capture the highest fraction of the total variable.

Table 3 - Relationships between independent variables and the dependent variable (attack quality) in the female and male gender.

Variable	Female			Male		
	X^2	p	Cramer's V†*	X^2	p	Cramer's V†*
Complex	3.131	0.209	0.079	0.217	0.897	0.25
Pass position	5.966	0.818	0.077	15.432	0.117	0.152
In-game role of passer	**19.388**	**0.001**	**0.138**	1.400	0.844	0.046
Pass quality	9.769	0.135	0.098	8.937	177	0.115
Setter's position	3.981	0.137	0.089	**6.123**	**0.047**	**0.135**
Setting type	6.688	0.755	0.081	5.555	0.851	0.091
Setting quality	**104.479**	**< 0.001**	**0.321**	**90.733**	**< 0.001**	**0.368**
Attack type	**56.713**	**< 0.001**	**0.334**	**28.115**	**< 0.001**	**0.290**
Attack direction	**19.642**	**0.033**	**0.139**	**27.429**	**0.002**	**0.202**
Block type of opponent	3.640	0.457	0.060	6.068	0.194	0.095

†Cramer's V: > 0.05 weak, > 0.1 moderate, > 0.15 strong, > 0.25 very strong association.
All significant relationships are presented in bold.

a very strong association with AQ, while RP and AD are characterized by a moderate association with AQ. There was no significant relationship between AQ and C, PP, PQ, SP, ST, and BT. So, these variables could not be included in the multinomial logistic regression model.

Multinomial logistic analysis for attack quality per gender

Table 4 summarizes all the model-fitting information of multinomial logistic regression for both genders. In addition to the predictors of the model that contained only the intercept, the fit between the final model and the data improved significantly, for the female gender χ^2 (18, N = 508) = 176.161, $p < 0.001$ and for the male gender χ^2 (16, N = 335) = 110.232, $p < 0.001$.

There was a good model fit (discrimination among levels of AQ) for both genders based on the relevant performance indicators. Thus, the next step was to examine which of the parameter estimates could affect the final model.

As shown in Table 5, significant unique contributions (in bold) were made for the male gender concerning SP, SQ and AT. On the other hand, for the female gender, the statistically significant independent variables were RP, SQ, AD and AT. So, from an initial point of view, the only common predictors for both genders are SQ and AT. The Cramer's V index assessed collinearity among independent variables (predictors) per gender. Variables exhibiting a Cramer's V value exceeding 0.25 were considered to have a strong correlation[34,35]. Based on this criterion, the model includes the predictor variables.

Female gender

Parameters estimates and odds ratios with their 95% confidence limits for the female gender are presented in Table 6. It should be noticed that the confidence interval is asymmetric, i.e., the point estimate of OR (Odds Ratio) does not lie in the exact centre of the confidence interval, because the log transformation was used to compute OR and then the antilog was taken to compute the lower and upper limits of the confidence interval.

SQ, RP, and AT predictors had significant parameters for comparing neutral (continued) to winning attacks. When setting quality is increased by one unit, the multinomial log-odds of having a winning versus a neutral attack would be expected to increase by $e^{1.522} = 4.583$ (C.I. 95%, 2.923-7.185). About RP, if a female outside hitter (HT) or a libero (LBR) were to pass the ball to the setter instead of other players (O), the odds of a winning instead of a neutral attack would be expected to increase by 3.679 (C.I. 95%, 2.923-7.185) for an OH and by 4.752 (C.I. 95%, 2.034-11.103) for an LBR player. Concerning attack type the odds of a winning instead of a neutral attack would be expected to increase by 6.068 (C.I. 95%, 2.575-14.299) for a strong attack (SA) instead of an off-speed attack (OFA).

SQ and AD predictors had significant parameters for comparing lost-to-win attacks. When SQ is increased by one unit, the multinomial log odds of having a winning versus a neutral attack would be expected to increase by 9.461 (C.I. 95%, 5.407-16.554). About AD, the odds of a lost instead of a win attack would be expected to increase by 2.446 (C.I. 95%, 1.079-5.547) if the direction of attack was Z5 instead of Z6.

Table 4 - Model fitting information for female and male gender.

Model	Female				Male			
	Model fitting criteria		Likelihood ratio tests		Model fitting criteria		Likelihood ratio tests	
	-2 Log likelihood	Chi-square	df	Sig.	-2 Log likelihood	Chi-square	df	Sig.
Intercept	407.340				254.205			
Final	231.178	176.161	18	**< 0.001**	143.973	110.232	16	**< 0.001**

All significant relationships are presented in bold.

Table 5 - Predictor's unique contribution in the multinomial logistic regression for the female and male gender.

Variables	Female				Male			
	-2 Log likelihood of reduced model	Chi-square	df	Sig.	-2 Log likelihood of reduced model	Chi-square	df	Sig.
Role of passer	**252.303**	**21.125**	**4**	**< 0.001**				
Setter's position					**151.420**	**7.447**	**2**	**0.024**
Setting quality	**318.640**	**87.461**	**2**	**< 0.001**	**197.608**	**53.635**	**2**	**< 0.001**
Attack direction	**254.123**	**22.945**	**10**	**0.011**	157.088	13.115	10	0.217
Attack type	**261.751**	**30.572**	**2**	**< 0.001**	**152.515**	**8.542**	**2**	**0.014**

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0; All significant relationships are presented in bold.

Table 6 - Parameters estimate contrasting attack quality versus each other level and variable for the female and male gender.

Gender	Attack quality[a]	Variable	B	Wald χ^2-test	Sig.	Exp (B)	95% confidence interval exp (B)	
							Lower bound	Upper bound
Female	Lost	Setting quality	**2.247**	**61.978**	**< 0.001**	**9.461**	**5.407**	**16.554**
		Attack direction						
		Z5	**0.895**	**4.585**	**0.032**	**2.446**	**1.079**	**5.547**
		Z6	0	.	.	.	.	.
	Neutral	Setting quality	**1.522**	**44.013**	**< 0.001**	**4.583**	**2.923**	**7.185**
		In-game role of passer						
		OH	**1.303**	**10.821**	**0.001**	**3.679**	**1.693**	**7.994**
		L	**1.599**	**12.960**	**< 0.001**	**4.752**	**2.034**	**11.103**
		Otherb[b]	0	.	.	.	.	.
		Attack type						
		SA	**1.803**	**16.997**	**< 0.001**	**6.068**	**2.575**	**14.299**
		OFA	0	.	.	.	.	.
Male	Lost	Setting 1uality	**2.160**	**37.599**	**< 0.001**	**8.675**	**4.349**	**17.306**
		Setter's position						
		FR	**0.924**	**4.835**	**0.028**	**2.518**	**1.106**	**5.736**
		BRb[b]	0	.	.	.	.	.
	Neutral	Setting Quality	**0.759**	**5.061**	**0.024**	**2.137**	**1.103**	**4.140**

[a]Win attack is the reference category for the dependent variable (attack quality).
[b]Reference category for the independent variables.
All significant relationships are presented in bold.

Figure 4 displays the two-dimensional map resulting from the multiple correspondence analysis applied to the contingency table of female skills data. The first two dimensions, namely those represented in the map, accounted for 67.92% of the total variance. The first (horizontal) dimension, explaining 42.96% of the total variance, may be considered to reflect the trend of the ideal sequential order of skills for a winning attack from a middle attacker, such as pass from the LBR or the OH, perfect setting and SA to the back row of the volleyball court (Z1, Z6, Z5) contrary to the sequential order for a neutral attack which is consisted from (very)good setting and OFA (roll shot or tip) to the front row of the volleyball court (Z2, Z3, Z4). The second dimension (vertical, 24.96% of the explained variance) may reflect the connection of SQ with the AQ, as perfect settings (P) and attacks with a positive outcome (W) lying to the right lower part of the plot, while moderate (M) and very good (VG) settings and attacks with non-positive (N or L) outcome lying to the upper left part of the plot.

Male gender

In Table 6 parameters estimates and odds ratios with their 95% confidence limits for the male gender are presented. The predictors SQ and SP had significant parameters for comparing lost to winning attacks, while the predictor SQ had significant parameters comparing neutral to winning attacks. When the setting quality is increased by one unit, the multinomial log odds of having a winning versus a lost attack would be expected to increase by 8.675 (C.I. 95%, 4.349-17.306) and versus a neutral attack would be expected to increase by 4.060 (C.I. 95%, 2.375-6.943). About SP, the multinomial log-odds of having a winning versus a lost attack would be expected to increase by 2.518 (C.I. 95%, 1.106-5.736) when the setter was in the rotations 1, 6, 5 (BR) with 3 attackers in the front row than when he was in the rotations 4,3,2 (FR) with 2 attackers in the front row.

Figure 5 displays the two-dimensional map resulting from the multiple correspondence analysis applied to the contingency table of male skills' attack data. The first two dimensions, namely those represented in the map, accounted for 76.92% of the total variance. The first (horizontal) dimension explains 46.63% of the total variance, while the second (vertical) dimension explains 30.29%. Both dimensions may reflect the importance of SQ to the AQ, as the categories of perfect setting (P) and win attack (W) are identified in the lower right part of the plot, while the categories of very good setting (VG) and neutral attack (N) are close in the upper left part of the plot.

Discussion

The purpose of this study was to investigate and compare the performance of middle players (MP) of both

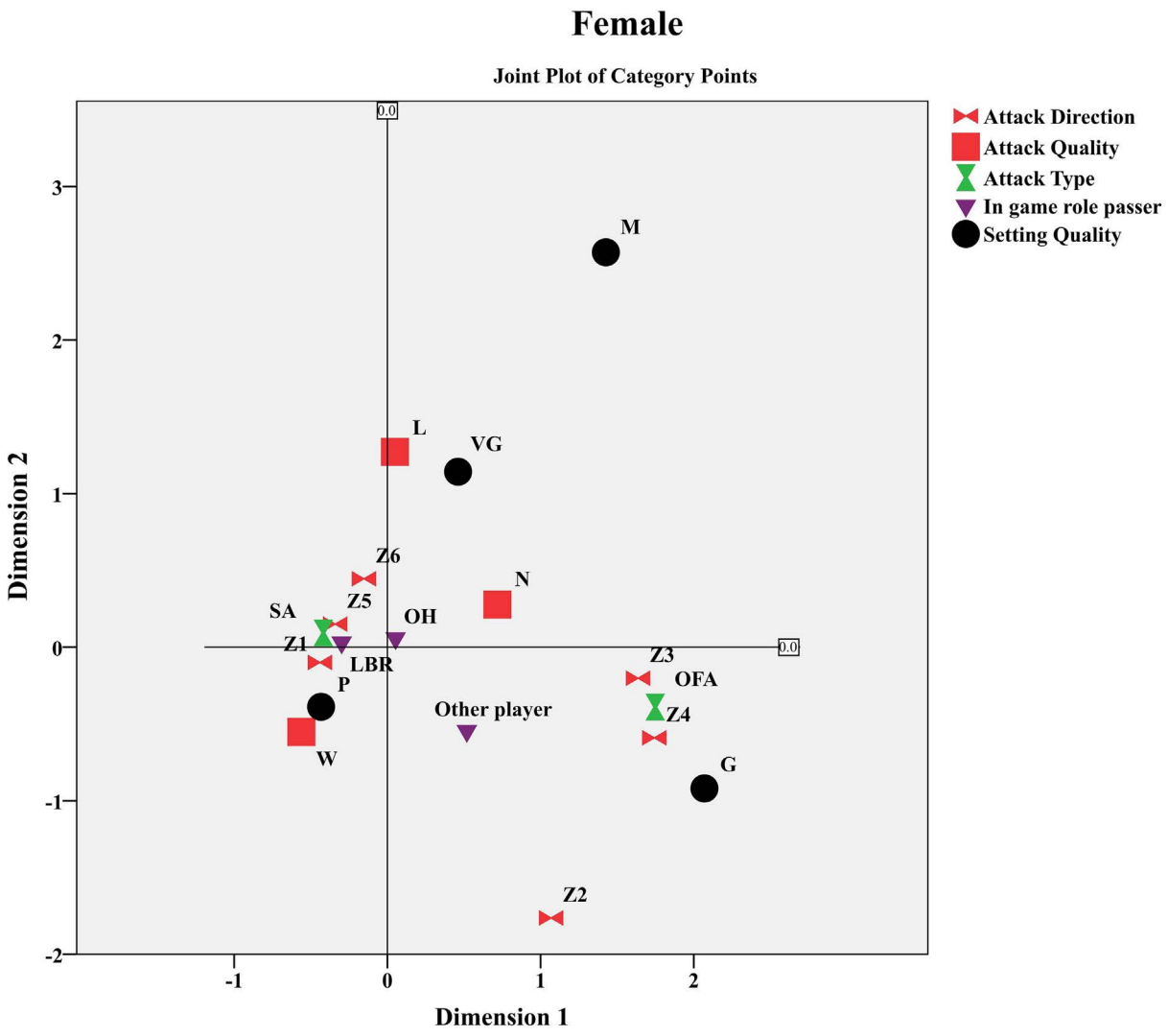

Figure 4 - Map obtained by the multiple correspondence analysis for female gender performed on the contingency table formed by the significant unique contributors role of passer, setting quality, attack type, direction and quality. The map displays the coordinates of categories of all variables in the two dimensions that capture the highest fraction of the total variable.

genders in terms of the pass, setting and attack parameters and the type of opponent block. The initial study hypothesis was supported by the findings, which demonstrated significant gender-based differences in several key attack parameters of the middle blocker (MP). Women attack mainly from the area behind the setter, even after just a good previous pass, against team block but with lower attack effectiveness than men who use to attack mainly in front of the setter, after an accurate previous pass against a single block. The main difference between genders was that women setters use to feed middle players even after just a previous good pass, while male setters send a remarkable percentage of their settings in the case of an excellent or very good previous passing action[3]. A possible explanation might be due to the one-leg attack executed from the right side-line (B2)[36].

Quick tempo attacks 11 and 21 require an accurate previous pass and the greatest degree of coordination between the setter and MP, while a B2 attack, as the flight time of the ball, is greater than a quick 11 or 21 attack[27] gives to the players (setter and MP) the chance to adjust their movements, even with a non-accurate previous pass, to organize an attack from the right sideline. The use of a B2 attack in connection with the introduction of an attack of position 6 for the opposite player[37] may create uncertainty in the opponents' block anticipation effort[38]. Thus, in female volleyball the availability of an MP to perform a quick attack[5] does not be ensured only by an accurate pass and the speed of setting close to the setter (1 m-2 m) as in male volleyball, but also with a non-accurate pass and the creation of a distance between setter and MP, who acts out of her usually playing area, in the middle of the net.

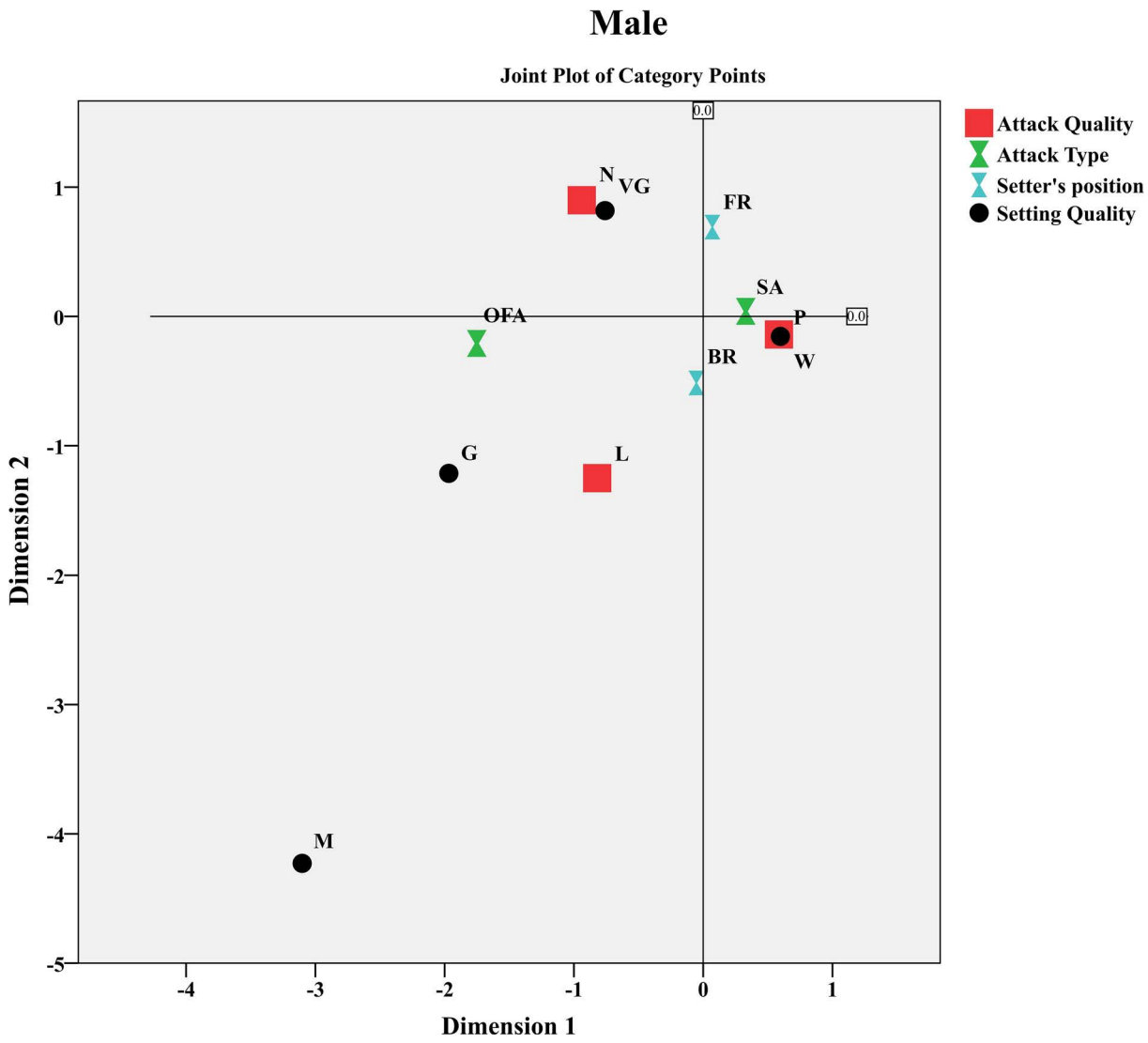

Figure 5 - Maps obtained by the multiple correspondence analysis for the male gender performed on the contingency table formed by the significant unique contributors setting quality, setter position, attack type and quality. The map displays the coordinates of categories of all variables in the two dimensions that capture the highest fraction of the total variable.

A general tendency emerges that the setter tends to disperse the attackers' positions, as in the men's game[2]. In this tendency the existence of an opposite player to the right side of the court for all team's rotations force male setters to take advantage of MP attack availability when moving in front of him (attacks 11, 21 and 31), while female setters targeting to cover the lack of a right side powerful hitter, especially in rotations 4,3,2 (setter in back line), take advantage of MP availability by moving her on their back using one-leg approach (attacks B1 and B2)[38,39]. As a consequence of this tendency can be considered the difference between genders relevant to the block composition of the opponents. In the men's game, a single block happened more often when the attack was performed by MP because most attacks of MP are fast and executed in the central lane of the net close to the setter[40].

Additionally, the existence of a fourth attacker from the central lane of the court (Zone 6) creates an advantage over the defending team, due to the numeric superiority of the attacking team in relation to the defence (4 attackers vs 3 blockers). Thus, in the most recurrent blocking system called man-to-man[41] the MP of the opponent had to play against two hitters at the central lane of the court. MP from the offensive line and outside hitter from the defensive line[42].

Contrary to this, in the women's game, the lower effectiveness[43,42] from the central lane of the court (Zone 6), the use of 2nd slow tempo setting[38] for the opposite player from zone 6 in rotations 4,3,2 and the use of the B2 attack type creates an equilibrium between the attacking and defending teams. Therefore, the opponents were allowed to build more often a team block against MP in

women than in men resulting in significantly lower attack effectiveness for women than men MP (by 11.4%). Nonetheless, MP in both genders has a higher percentage of win attacks compared to the opposites and outside hitters[38,42,44]. Another possible consequence of the more frequent team block against women MP would be the lower effectiveness of MP when directing their spike to Z5, as the odds of a lost attack were almost doubled, maybe because of the availability of two opponent blockers, OH and MP, to block the B2 attack of the MP, as women apply slower attack tempos[4,13] and the teams followed zone-blocking system which increases the occurrence of team block[45].

Regarding the factors that reveal the attack performance of the MP, it confirmed the high dependency of the attacking quality on the setting quality. The improvement of setting quality by one unit (moderate to good, good to very good, very good to perfect) increases by approx. 9 the odds for a winning versus a lost attack and by approx. 4 the odds for a winning versus a neutral attack, for both genders. Thus, is not only the factor setting quality important for both genders but also the magnitude of its significant parameters.

Concerning the type of attack, previous studies showed that women, independently of their in-game role, use off-speed attacks more frequently compared to men because of the lower absolute power[22] and their tendency to reduce risk during the offence[46]. This tendency has already been confirmed by recent studies for opposite players[38] and outside hitters[42]. Contrary to this, in the current study, both genders of MP use an off-speed attack with equal frequency, but women with lower effectiveness. As multinomial logistic regression highlights the importance of a strong instead of an off-speed attack as the log odds for a winning attack were 6 times greater. This should lead women MP to use rarely off-speed attacks, such as tips or roll shots.

Regarding the previous passer, for women's volleyball, a novel finding by this study was that the pass from the LBR instead of the Opp or the MP increases the odds of a winning attack from MP by 5 times, while the pass from the OH increases the odds by 4. Women teams' coaches should organize their team defence, especially during the free ball or downball complex[47] targeting to give more responsibilities for the first ball touch primarily to the LBR and secondly to the OH releasing the MP and the Opp to prepare for their attacking duties. An increase in the first contact represents better conditions to carry out the setting, which may affect the result of the rally[48,49].

Concerning the male gender and the factors that reveal the attack performance of the MP, an imbalance between rotations with the setter in the front line and the back line appeared, as the log odds of having a winning versus a lost attack executed by the MP when setter in the front than back row are about 2.5. Thus, the choice of many high-level volleyball coaches to replace the setter and the opposite player with their vice-versa having 3 attackers in the front row increases the probability of a winning attack not only for the opposite player[38] but also for the MP.

As a limitation, the fact that this study analyzed the attack options of top-level players should be highlighted. Perhaps the results and the discussion achieved may not be extrapolated to another level of players. Additionally, the high level of the opponent and the match status are factors that may influence the distribution of the offensive game and the attack movement of the player. Considering that sports evolve very quickly, future studies should analyze whether these findings coincide with current game patterns, as the sample of this study corresponds to the 2018 Men's and Women's World Championships. Comparing the results of this study with recent analysis could provide a frame of reference to verify the evolution of the attack patterns and effectiveness for middle players between genders in elite volleyball.

In terms of practical application, this study provides useful insights to coaches of both genders. Coaches of female teams should emphasize to the availability of four attackers in all rotations by adding an attack point from zone 6 in order to create favourable conditions for a winning attack from the MP, should organize their free ball complex giving more duties for the first touch of the ball primarily to the libero player and should lead their MPs to use strong than off-speed attacks. On the other hand, coaches of male teams should prepare situations with a greater variety of locations for the MP, targeting to improve the unpredictability of the attack[2]. Additionally, they should prepare a setter-opposite vice versa substitution to increase offensive effectiveness for the opposite and middle players.

Conclusions

In conclusion, concerning MPs the two genders vary in some aspects of the game at the top level. Women MPs attack mainly from the area behind the setter, even after a good first pass, against a team block but with lower attack effectiveness than men MPs who use to attack mainly in front of the setter, after an accurate first pass against a single block. The attack effectiveness for both genders depends highly on the setting quality. In female volleyball, to increase effectiveness libero player is preferable to execute the first touch of the ball and MP to avoid off-speed attacks and to upgrade the effectiveness of spikes to zone 5, while in male volleyball the existence of three attackers in the front row increases the odds for a winning attack.

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