

Original Research

A Comprehensive Analysis of the Serve Reception Zone, Set Zone and Attack Quality of the Top-Level Volleyball Players

Ali Fatahi¹, Razieh Yousefian Molla^{2*}, Sotirios Drikos³, Shihab Aldin Alriyami⁴ and Saed Jadidoleslam⁵

¹ Department of sports biomechanics, Central Tehran branch, Islamic Azad University

² Islamic Azad University of Karaj, Department of Physical Education and Sport Sciences, Karaj, Iran.

³ School of Physical Education and Sport Science, National and Kapodistrian University of Athens, Greece.

⁴ Department of Sports exercise Physiology, Shahid Beheshti University, Tehran, Iran.

⁵ National volleyball coach, Iran.

* Correspondence: raziheyousefian@yahoo.com  Orcid ID n^o 0000-0002-1527-7737
Received: 16/04/2022; Accepted: 14/06/2022; Published: 30/06/2022

Abstract: The game analysis is known as a useful tool for understanding the level of technical-tactical performance of volleyball. As one of the main characteristics of volleyball is defined as the intense relationship between its skills and concluded performance, the present study aimed to perform a comprehensive analysis of the serve reception zone, set zone and attack quality of the top-level volleyball players. The analysis process included reviewing the videos of the games by an experienced scout man who was an expert analyst and specialist in the knowledge of volleyball skills. Initially, during each game video checking, data were collected, and irrelevant/invalid outputs were deleted. Data were exported to the Data Volley special volleyball analysis software. Bivariate associations were assessed for pairs of variables with Pearson's chi-squared tests. Statistical significance was set at $p < 0.05$. Moreover, the effect size was calculated in terms of Crammer's V, with values of < 0.1 , $0.1 - 0.3$ and > 0.5 for small, medium, and large effects respectively. The results showed that there were significant relationships between reception zone with setting zone, setting zone with attack quality as well as reception zone with attack quality. Coaches may consider the relationship between critical skills of volleyball to promote their team performance.

Keywords: Reception, Set, attack, volleyball, Game's Analysis

1. Introduction

Volleyball, as a cyclic complex team sport, is based on six basic skills, including serve, pass, set, block, dig and attack (Bertucci, 1982). One of the main characteristics of volleyball is defined as the

intense relationship between its skills and concluded performance, so except serve, other skills are affected by the previous skill and consecutively would affect the former one (González-Silva et al., 2020). Therefore, through the complex evaluation of volleyball games, the researchers have concluded that



scoring in volleyball depends on the optimality of successive performances between different skills with various tactics (Stutzig et al., 2015).

Serve reception is the first skill in the initiation of the scoring process (Hileno et al., 2020). Although previous studies have widely cited an outstanding link between the attacking quality and success as a key factor (Marcelino et al., 2008), some other studies have introduced high-quality reception as a major factor (Hughes & Daniel, 2003), mainly due to the definite influence on the other skills (González-Silva et al., 2020). Indeed reception, pass and defense (on the net/ in the court) are continuous skills that will not usually earn points directly (Marcelino et al., 2008), but insufficient attention to the quality of the reception performance as well as the continuity of them, may cause a loss of the points, sets, and at the end, result (González-Silva et al., 2020). Reception of the opponent's team serve is one of the most fundamental and vital factors for the proper execution of a program and pre-designed plans of the team. Teams try to strengthen the reception lineup to strengthen the first stage of the mentioned attack steps. Conversely, the server teams also consider special planning to apply this skill and disrupt the theory of the receiving lineup of the opponent's team.

In modern volleyball, attack efficiency is the most important predictor of team success, which can be implemented by various methods, such as spike (Challoumas & Artemiou, 2018). In other words, due to the comparative evaluation of the professional team's performance, the attack is the main factor of the victory (Monteiro et al., 2009) and would lead to higher scores achievement (Marcelino et al., 2008; Mesquita et al., 2007). Generally, two types of attacks are performed in volleyball. The first type, which is known as Complex I, is the method of changing the serve of the opponent team and the attack following the first reception (reception, pass (set) and attack). The second type, which is known as Complex II, is the method of transition and attack from the free ball (changing from the defensive situation to the offensive situation, including serve,

block, defense, and counter-attack) (Palao et al., 2007). Usually, the best attack occurs in the first type and causes better and faster effectiveness, while in the second type, the execution of the attack will be with a slower rhythm and with an increasing defensive performance (Castro & Mesquita, 2008; Palao et al., 2007). In this way, in volleyball, the attack seems to be related to the type of perception that has been made before (Mesquita et al., 2007). Besides attack importance and attack quality, service reception has a special effect on the performance of the set, in terms of quality and the strategy of the setter and the effectiveness of the attack (Silva et al., 2013). In addition, another important factor that determines the next action's efficacy is the setting. The setting is an important task in volleyball, from technic and tactile, as it affects the attack's quality. The better the quality of the setter, the better the performance of the attackers (Silva et al., 2013).

The game analysis and related skills are known as useful tools for understanding the level of technical-tactical performance of the volleyball (Afonso et al., 2010). In the other words, games analysis is the main essential factor, to identify the important issues of professional and elite players (Coutinho et al., 2008; Hughes & Bartlett, 2002), and also, provides the possibility of predicting the consequent actions of the players tactically. Furthermore, It provides a more specific perspective for designing exercise programs (Stutzig et al., 2015). In this perspective, old statistical and non-statistical analyses are usually limited (Hale, 2012), but nowadays, the new analytical methods provide a broader view of the game's patterns (Passos et al., 2017). One of the most comprehensive methods of game analysis is monitoring the match videos and performing advanced statistical analysis of the skills. These analyses cover a wide range, from the players, positioned and their lineup on the court to their individual/team behaviours. Most statistical and analytical studies in volleyball have concentrated purely on the analysis of the obvious skills, such as serve,

attack or defense (Afonso et al., 2010; Buscá et al., 2012; Marcelino et al., 2008) and few studies have focused on the related and interactive skills, such as serve reception and attack (González-Silva et al., 2020). On the other hand, most volleyball analysis studies have been performed on adult women volleyball players (Castro & Mesquita, 2008; Drikos et al., 2018; Miskin et al., 2010), while the skills resulting in reception and attack in this sport are affected by gender (Kountouris et al., 2015) and even, some skills such as serve type and attack type are significantly different between men and women (Afonso et al., 2010; Afonso & Mesquita, 2011). Therefore, the present study aimed to do a comprehensive analysis of the serve reception zone, set zone and attack quality per zone of attack of the top-level male volleyball players.

2. Materials and Methods

The statistical population of this research consisted of Iranian men's premier League games of 2019-2020 of the adult age groups including the preliminary, play-off and final round of fourteen teams were considered for analysis.

The games were recorded by a SONY® camera with a frequency of 24 Hz. The camera was mounted behind the court, a place that will completely cover all the different situations and conditions of the game. The analysis process included reviewing the videos of the games by an experienced scout man who was an expert analyst and specialist in the knowledge of volleyball skills. Initially, during each game video checking, data were collected, and irrelevant/invalid outputs were deleted. Data were exported to the special volleyball analysis software – Data volley by Data Project.

To assess the position of the reception (R), the reception area of the ball was divided into 3 equal lanes, measuring 3x9m (27m²), as suggested by Sotiropoulos et al. (2020). The names of the areas were derived from the location of the zones on the vertical axis of the court [(Left-L), (Middle-M), (Right-R) lane] (Figure 1).

The position of attack (A), is defined as the area of the court where the attack strike was made. The categories were: positions (P) 1, 6, 5, 4, 3, and 2 according to Ramos et al. (2017). If the attacker's feet were in two adjacent zones, the airspace where the attack took place was considered the attack zone.

For the evaluation of the attack quality an adaptation of instruments was proposed by Eom & Schutz (1992) Marcelino et al. (2011) and Costa et al. (2017) were used. The observer was asked to categorize the attack quality according to the effectiveness of the skill on a four-level ordinal tactical scale with the minimum level indicating an attack error and the maximum level corresponding to an attack kill (direct point). The levels of the entire evaluation scale were 1st) lost point (L) because of an error or blocked attack, 2nd) moderate attack (M), a condition in which the ball is in the opponent court and the opponent team has the possibility of counterattack, 3rd) good attack (G), condition of a second attack for the attacking team, 4th) win attack (W), direct point for the attacking team.

The reliability of the observations was assured by the intraobserver agreement within a 15-day interval. Ten per cent (10%) of the total observations were analyzed, according to the minimum value given in the literature (Tabachnick & Fidell, 2007). The intra-rater reliability coefficient was estimated using Cohen's kappa coefficient. The coefficient was 0.92 for intra-rater reliability, indicating very high consistency in the assessment procedure. As the acceptable value of Adjusted K Cohen was set at 0.8 (Altman, 1991) and the values for reception zone, setting zone and attack quality equalled 0.91, 0.95, and 0.89, concerning the intra-observer reliability. Inter-observer reliability was examined by a second independent volleyball expert who was asked to evaluate all the skills of the same sample. The weighted kappa values for this procedure equalled 0.89, 0.80, 0.83 and for the reception zone, setting zone and attack. A total Adjusted K Cohen value of 0.84 was set for inter-observer reliability and showed a very good value (Altman, 1991).

Bivariate associations were assessed for pairs of categorical variables with Pearson's chi-squared tests of independence. Statistical significance was set at $p < 0.05$. Moreover, the effect size was calculated in terms of Crammer's V, with values < 0.1 , $0.1 - 0.3$ and > 0.5 for small, medium, and large effects, respectively. Also, standardized residuals for each cell were calculated. A residual is a difference between the observed and expected values for a cell. The larger the residual, the greater the contribution of the cell to the magnitude of the resulting chi-square obtained value. Adjusted residuals beyond the range of ± 2 (is used by convention instead of 1.96) mean that the specific cell can be considered as a major contributor, if it is > 2 , or a very weak contributor, if it is beyond -2 , to the overall chi-square value.

To determine which combinations of the variables' categories were the most responsible for the association when the null hypothesis of independence was rejected, two-way contingency tables were graphically displayed using mosaic plots. 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 $\alpha = 0.05$ and $\alpha = 0.001$ levels, respectively. All the previously mentioned characteristics of mosaic plots allow for visually assessing the structure of the association between variables (Zeileis et al., 2007).

A further analysis was performed using multiple correspondence analysis (MCA), a procedure allowing to represent graphically the information contained in a multiway contingency table (Greenacre & Blasius, 2006), was carried out on reception/attack data. The interpretation of MCA is based upon proximities between points in a dimensional map. The analysis of two-way consistency tables was performed with the R statistical software (R Development Core Team, 2011), using the package vcd (Meyer et al., 2006; Zeileis et al., 2007).

Table 1. Descriptive data concerning variables under analysis

Variable	Category	Setting zone (% of attempts, adjusted residuals)				
		Zone 4	Zone 3	Zone 2	Zone 1	Zone 6
Reception zone	Right lane	28.6 [^]	21.1	20.6*	16.9	12.8 [^]
	Middle lane	28.5 [^]	20.9	20.1	17.1*	13.4*
	Left lane	31.7*	21.0	19.9 [^]	16.2 [^]	11.2 [^]

‡ The sign * indicates residuals are > 2 and the sign [^] indicates that adjusted residuals are < -2

Table 2. Descriptive data concerning variables under analysis

Variable	Category	Attack quality (% of attempts, adjusted residuals)			
		Win point (W)	2 nd attempt (G)	Ball to the opponent (M)	Lost point (L)
Reception zone	Right lane	55.9	5.8*	20.8	17.5
	Middle lane	56.4	5.9	20.2 [^]	17.5
	Left lane	56.1	6.1	20.8	17.0 [^]
Setting zone	Zone 4	55.7 [^]	5.7 [^]	21.3*	17.3
	Zone 3	56.9	6.6*	20.3	16.2 [^]
	Zone 2	55.8	5.9	21.1	17.2
	Zone 1	56.1	5.5 [^]	19.8 [^]	18.5*
	Zone 6	56.5	5.6 [^]	19.6 [^]	8.2*

‡ The sign * indicates adjusted residuals are > 2 and the sign [^] indicates that adjusted residuals are < -2

Table 3. Relationships between independent variables and the dependent variable (attack quality)

Variable	X ²	Df	p	Cramer's V‡
Reception zone X Setting zone	294.889	12	≤0.001	0.027
Reception zone X Attack quality	19.612	6	0.003	0.007
Setting zone X Attack quality	173.218	12	≤0.001	0.017

‡Cramer's V: <0.1 small, 0.1- 0.3 medium >0.5 large effect.

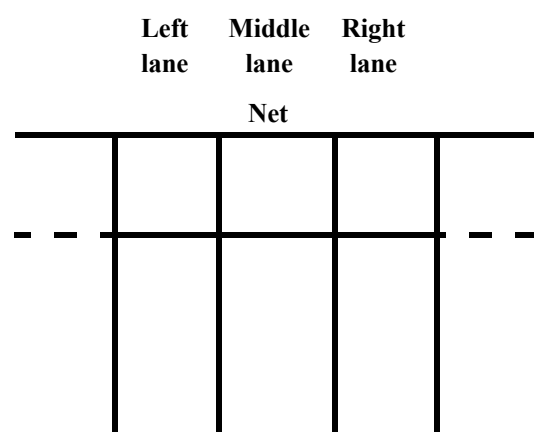


Figure 1. The three-area subdivision of the volleyball court is used to define the area of the receiver position.

3. Results

The present study aimed to examine the association of the serve reception zone, set zone and attack quality per zone of attack. Within this frame attacks from zone 5 had a zero frequency of occurrence and have been removed from the subsequent analysis. Therefore, 204.165 receptions were finally considered. The frequencies of reported data of independent variables as well as Chi-square analyses are presented in Table 1- Table 3. The structure of the relationships revealed by mosaic plots (Figure 2) is described in the following:

Reception zone/ Setting zone

The majority of the settings were directed to zone 4, independently of the reception zone (28.65%, 28.5% and 31.75% for right, middle and left lanes of the reception area). In contrast, the smallest amount compared to other setting zones was directed to zone 6 (12.85%, 13.4% and 11.2% for the

right, middle and left lanes of the reception area). Also, a specific ranking sequence for all the setting zones existed across all the reception zones (zones 4, 3, 2, 1, and 6 in descending order). The statistical analysis showed that there was a significant relationship between the reception zone and setting zone, $X^2(12, N= 204.165) = 294.89$, $p \leq .001$ and a weak effect was found ($V=0.027$).

Reception zone/ Attack quality

The statistical analysis showed that there was a statistically significant relationship ($p=.003$) between the reception zone and the attack quality, $X^2(6, N= 204.16) = 19.612$, $p=.003$ accompanied by a weak effect ($V=0.007$). The majority of attacks ended up as win points independently of the reception zone (55.9%, 56.4% and 56.1% for right, middle and left lane of reception area). Additionally, a specific ranking sequence for all the levels of attack quality existed across all the reception zones (win point, 4, 3, 2, 1, 6 in descending order).

Setting zone/ Attack quality

Most of the attacks ended up as win points, independently of the setting zone (55.7%, 56.9%, 55.8%, 56.1% and 56.5% for setting zone 4, 3, 2, 1 and 6). In contrast, the smallest amount compared to others resulted in the continuation of the rally a 2nd attempt for the attacking team (12.85%, 13.4% and 11.2% for the right, middle and left lanes of the reception area). Also, a specific ranking sequence for all the setting zones existed across all the reception zones (zones 4, 3, 2, 1, and 6 in descending order). The statistical analysis showed that there was a significant relationship between the setting zone and attack quality, $X^2(12, N= 204.165) = 173.22$, $p \leq .001$ and a weak effect was found ($V=0.017$).

All the relationships between variables characterized by strong association as observed p-values were highly significant, but with a small effect size. As the chi-square statistic is a measure of effect size confounded by the sample size, at large sample sizes, as in this study (N=204.165) even small effects can be significant.

Figure 3 displays the two-dimensional map resulting from the multiple correspondence analysis applied to the three-way contingency table of serve data the first two dimensions, namely those represented in the map, accounted for 66.6% of the total variance. The first (horizontal) dimension, explaining 33.59% of the total variance, may be considered to reflect the trend of setting selection concerning the reception zones. Receptions from wing reception zones (left and right lane) connect with setting in the wings of offensive mode (zones 1, 2 and 4), whereas receptions from the middle lane connect with setting to the middle lane of the offence (zones 3 and 6). The second dimension (vertical, 33.08% of the explained variance) may instead reflect the positive/negative outcome of an attack concerning the setting position and the reception zone. Attacks that involve a positive outcome for the attacking team such as a winning point or a chance for a 2nd attempt lie at the bottom of the plot, while an attack with a negative outcome for the attacking team (ball to the opponent or lost point) appears in the upper part of the plot. Finally, the point indicating a win attack on the plot is in connectivity with the right lane of reception and with setting selections of zones 4 and 1.

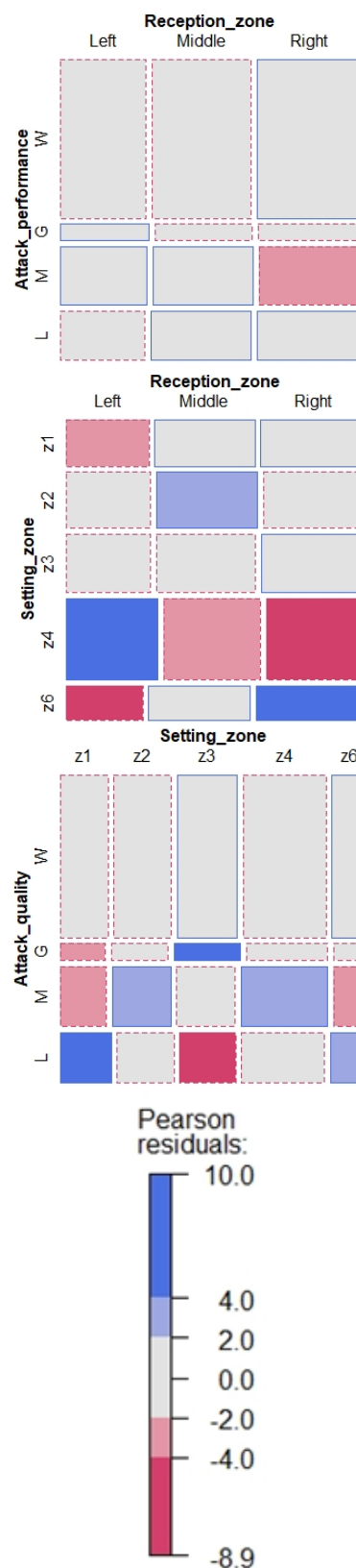


Figure 2. Mosaic plots of the two-way contingency tables of complex 1 skills. For each cell, the standardized Pearson residual of that cell is indicated using different cell shadings and edges (dash lines for negative values and continuous lines for positive values).

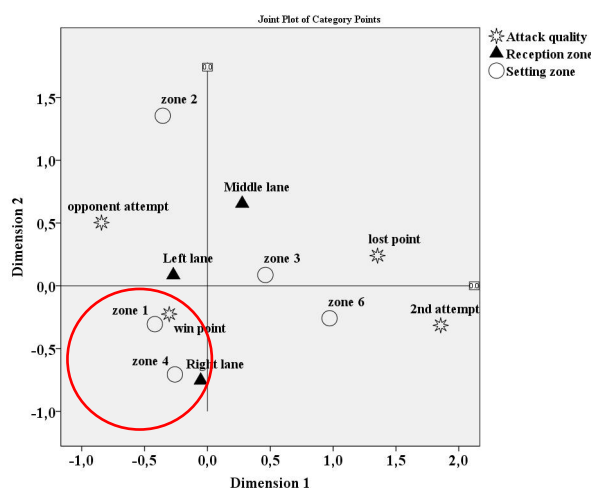


Figure 3. Map obtained by the multiple correspondence analysis performed on the three-way contingency table formed by reception zone, setting zone and attack quality. The map displays the coordinates of categories of all variables in the two dimensions that capture the highest fraction of the total variable.

4. Discussion

This study aimed to investigate the relationships between the reception zone, setting zone and attack quality among professional volleyball players. The results showed that there were significant relationships between reception zone with setting zone, setting zone and attack quality as well as reception zone and attack quality.

To date, no similar document has been found including the same in the evaluation of the association between reception zone, set zone and attack quality. However, all the other similar studies were consistent with the results extracted from the data in this research. Monteiro et al. (2009) investigated the relationship between defence and attack quality in male volleyball players and like our study found that the attacking quality is highly correlated with the defence quality.

Araújo et al. (2020) focused on the relationship between reception skill and attack efficiency among the male and female players during the Rio 2016 Summer Olympics and concluded that in both women and men, the results of reception quality showed a predicted power in the attack and receipts that allow organized attacks, will end in points. The quality of the reception

will play an outstanding role in winning the games in volleyball. Optimum reception would lead to a comfortable condition for the setters to manage the tactical plans.

Costa et al. (2017) also studied the predictive factors of attack from zone no. 4 and found that reception, attack speed, counterattack speed and attack power were the main factors predicting the impact of the attack in zone no. 4. In addition, they concluded that earning points in professional male volleyball requires a high-quality reception. Also in this study, zone no 4 was found as the important zone in the relations of reception/attack quality and sett/attack quality and also the data showed that this zone has the highest importance in receiving. In this way, Palao et al. (2007) also published their study with the result that the use of fast tempo spikes and the use of the line spike both increase spike performance, and the ball contacting the block reduces spike performance. The zone most used by males and females was zone no. 4 (left side of the net) both inside-out and in counterattack. Zone no. 4 in volleyball is the best option for the attack according to the huge and wide space for the attackers to perform spikes. In this position, for the right-handed players, this position is well defined and easy to attack (Drikos et al., 2022).

Costa et al. (2014) performed another study focused on the effectiveness of the attack, its impact and its type in professional female volleyball players. They concluded that a significant relationship exists between the block and the speed of attack, and the speed of attack itself has a negative and inverse relationship with impact quality. Although this study is not directly related to our research but insists on the importance of attack and its influence and impression on other tasks. Also, Stutzig et al. (2015) in a study stated that the best predictors for results and team levels are variables (effectivity of counter-attack, effectivity of medium and slow attack-tempo) related to complex 2 (action sequences of defending, setting and counter-attacking). In contrast, the impact of complex 1 variables (action sequences of reception, setting and attacking)

is marginal (Stutzig et al., 2015). In contrast, Afonso et al. (2010) in a contradict investigation with our study on analysis of the setter's tactical action in high-performance women's volleyball stated that Attack efficacy emerged as independent of the setter's action, although the latter largely influenced the type of block opposition. Hence, match analysis provides a window into aspects involving the tactical actions of high-level athletes. Maybe one of the most effective reasons for this inconsistency is their study was on female volleyball players whilst ours was on male professional players. Setters are the creative element of the game. According to their intelligence and experience, they will decide to recruit the best option to win the game. The position of the setter, as well as the the setting positions, are important parameters determining the effectiveness of the attack.

Grgantov et al. (2018) in a study in line with our study on intra and inter-zone differences of attack and counterattack efficiency in elite male volleyball cleared that there were significant differences in the efficiency of spikes in attacks and counterattacks from various zones of the volleyball court and between winning and losing teams. And their obtained results substantiate the importance of spiking, both in the attack and counterattack, for winning a volleyball set, and indicate the specific values of spiking in the attack and counterattack from various zones, or both winning and defeated teams (Grgantov et al., 2018).

González-Silva et al. (2020) stated that criteria related to reception (reception efficacy) and setting (setting zone, type of set, a set's area, and set tempo) determined set efficacy. Specifically, positive and negative receptions and settings from acceptable and nonacceptable zones reduced perfect setting. In contrast, the jump set toward zones three and six and the first and second tempo increased perfect setting.

Therefore, since success in volleyball requires accurate and precise planning for each rally, coaches and game analysts spend a lot of time reviewing and analyzing all

activities, and in other words fine skills of the game, to be able to create a systematic relationship between these skills. As mentioned, the attack is the main skill in scoring points in volleyball and to spike is to dominate winning or losing matches. Proper execution of this skill requires high-quality reception and sending the appropriate set by the team setter. As a result, the explanation of this article shows the importance of considering the quality of reception and set, both of which also affect the quality of the attack (Afonso et al., 2010; Costa et al., 2011; Mesquita et al., 2007).

5. Practical Applications.

The present study suggests that a relationship exists between the reception zone and the attack zone. Basically, in volleyball, it is clear that the setters, as the manager of the court, mainly tend to set to the attacking areas on the net after the serve reception. The result of this study confirms that the setter as team manager in the court plans to distribute sets to feed the attackers based on the reception zone.

Supplementary Materials: None

Funding: None

Conflicts of Interest: No potential conflict of interest was reported by the authors.

References

- Afonso, J., & Mesquita, I. M. R. (2011). Determinants of block cohesiveness and attack efficacy in high-level women's volleyball. *European Journal of Sport Science*, *11*(1), 69–75. <https://doi.org/10.1080/17461391.2010.487114>
- Afonso, J., Mesquita, I. M. R., Marcelino, R., & Silva, J. A. (2010). Analysis of the setter's tactical action in high performance women's volleyball. *Kinesiology*, *42*(1), 82–89.
- Altman, D. G. (1991). *Practical Statistics for Medical Research*. Chapman & Hall.
- Araújo, C. R. P., Tosini, L., Freire, A. B., Costa, G. D. C. T., & Meira JR, C. M. (2020). Reception-attack relation in men's and women's volleyball during the Rio 2016 Olympics. *Journal of Physical Education and Sport*, *20*(3), 2008–2012.

- <https://doi.org/10.7752/jpes.2020.s3271>
- Bertucci, B. (1982). *Championship volleyball* (Leisure Press. (ed.); The West P).
- Buscá, B., Moras, G., Javier, P. A., & Rodríguez-Jiménez, S. (2012). The influence of serve characteristics on performance in men's and women's high-standard beach volleyball. *Journal of Sports Sciences*, 30(3), 269–276. <https://doi.org/10.1080/02640414.2011.635309>
- Castro, J., & Mesquita, I. M. R. (2008). Estudo das implicações do espaço ofensivo nas características do ataque no Voleibol masculino de elite. *Revista Portuguesa Se Ciências Do Desporto*, 8(1), 114–125.
- Challoumas, D., & Artemiou, A. (2018). Predictors of attack performance in high-level male volleyball players. *International Journal of Sports Physiology and Performance*, 13(9), 1230–1236. <https://doi.org/10.1123/ijsp.2018-0125>
- Costa, G. D. C. T., Afonso, J., Barbosa, R. V., Coutinho, P., & Mesquita, I. M. R. (2014). Predictors of attack efficacy and attack type in high-level Brazilian women's volleyball. *Kinesiology*, 46(2), 242–248.
- Costa, G. D. C. T., Caetano, R. C. J., Ferreira, N. N., Junqueira, G., Afonso, J., Plácido Costa, R., & Mesquita, I. M. R. (2011). Determinants of attack tactics in youth male elite volleyball. *International Journal of Performance Analysis in Sport*, 11(1), 96–104. <https://doi.org/10.1080/24748668.2011.11868532>
- Costa, G. D. C. T., Pereira Maia, M., Evangelista, B. F. de B., Ceccato, J. S., Freire, A. B., Milistetd, M., Moraes, J. C., & Ugrinowitsch, H. (2017). Volleyball: Analysis of attack performed from the backcourt on men's Brazilian volleyball superleague (Brazilian championship). *Revista Brasileira de Cineantropometria e Desempenho Humano*, 19(2). <https://doi.org/10.5007/1980-0037.2017v19n2p233>
- Coutinho, P., Afonso, J., Mesquita, I. M. R., & Marcelino, R. (2008). The effect of the zone and tempo of attack in the attack's efficacy, in elite female volleyball. In P. O'Donoghue & A. Hökelmann (Eds.), *World Congress of Performance Analysis of Sport VIII* (pp. 501–504). Otto-von-Guericke-Universität Magdeburg.
- Drikos, S., Angelonidis, Y., & Sobonis, G. (2018). The role of skills in winning in different types of set in women's volleyball. *International Journal of Performance Analysis in Sport*, 18(6), 950–960. <https://doi.org/10.1080/24748668.2018.1528714>
- Drikos, S., Sotiropoulos, K., Gkreka, S., Tsakiri, M., & Barzouka, K. (2022). Variations in Attack Patterns between Female and Male outside hitters in top-level Volleyball: *International Journal of Sports Science and Coaching*. <https://doi.org/10.1177/17479541221075723>
- Eom, H. J., & Schutz, N. R. (1992). Transition playing team performance of volleyball: A log linear analysis. *Research Quarterly for Exercises and Sport*, 63(3), 261–269.
- González-Silva, J., Fernández-Echeverría, C., Conejero, M., & Moreno, M. P. (2020). Characteristics of Serve, Reception and Set That Determine the Setting Efficacy in Men's Volleyball. *Frontiers in Psychology*, 11(February), 1–9. <https://doi.org/10.3389/fpsyg.2020.00222>
- Greenacre, M. J., & Blasius, J. (2006). *Multiple Correspondence analysis and related methods*. Chapman & Hall/CRC.
- Grgantov, Z., Jelaska, I., Suker, D., & Šuker, D. (2018). Intra and Interzone Differences of Attack and Counterattack Efficiency in Elite Male Volleyball. *Journal of Human Kinetics*, 65(1), 205–212. <https://doi.org/10.2478/hukin-2018-0028>
- Hale, T. (2012). Do Human Movement Scientists Obey the Basic Tenets of Scientific Inquiry? *Quest*, 53(2), 202–215. <https://doi.org/10.1080/00336297.2001.10491740>
- Hileno, R., Arasanz, M., & García-De-Alcaraz, A. (2020). *The Sequencing of Game Complexes in Women's Volleyball*. 11:739. <https://doi.org/10.3389/fpsyg.2020.00739>
- Hughes, M., & Bartlett, R. M. (2002). The use of performance indicators in performance analysis. In *Journal of Sports Sciences* (Vol. 20, Issue 10, pp. 739–754). Taylor & Francis. <https://doi.org/10.1080/026404102320675602>
- Hughes, M., & Daniel, R. (2003). Playing patterns of elite and non-elite volleyball. *International Journal of Performance Analysis in Sport*, 3(1), 50–56. <http://www.ingentaconnect.com/content/uwic/ujpa/2003/00000003/00000001/art00007>
- Kountouris, P., Drikos, S., Aggelonidis, I., Laios, A., & Kyprianou, M. (2015). Evidence for Differences in Men's and Women's Volleyball Games Based on Skills Effectiveness in Four Consecutive Olympic Tournaments. *Comprehensive Psychology*, 4, 30.50.CP.4.9. <https://doi.org/10.2466/30.50.cp.4.9>
- Marcelino, R., Mesquita, I. M. R., & Afonso, J.

- (2008). The weight of terminal actions in Volleyball. Contributions of the spike, serve and block for the teams' rankings in the World League 2005. *International Journal of Performance Analysis in Sport*, 8(2), 1–7. <https://doi.org/10.1515/1559-0410.1348>
- Marcelino, R., Mesquita, I. M. R., & Sampaio, J. (2011). Effects of quality of opposition and match status on technical and tactical performances in elite volleyball. *Journal of Sports Sciences*, 29(7), 733–741. <https://doi.org/10.1080/02640414.2011.552516>
- Mesquita, I. M. R., Manso, F. D., & Palao, J. M. (2007). Defensive Participation and Efficacy of the Libero in Volleyball. *Journal of Human Movement Studies*, 52(2), 95–108.
- Meyer, D., Zeileis, A., & Hornik, K. (2006). The Strucplot Framework: Visualizing Multi-way Contingency Tables with vcd. *Journal of Statistical Software*, 17(3).
- Miskin, M. A., Fellingham, G. W., & Florence, L. W. (2010). Skill Importance in Women's Volleyball. *Journal of Quantitative Analysis in Sports*, 6(2). <https://doi.org/10.2202/1559-0410.1234>
- Monteiro, R., Mesquita, I. M. R., & Marcelino, R. (2009). Relationship between the set outcome and the dig and attack efficacy in elite male Volleyball game. *International Journal of Performance Analysis in Sport*, 9(3), 294–305. <https://doi.org/10.1080/24748668.2009.11868486>
- Palao, J. M., Santos, J. A., & Ureña, A. (2007). Effect of the manner of spike execution on spike performance in volleyball. *International Journal of Performance Analysis in Sport*, 7(2), 126–138. <https://doi.org/10.1080/24748668.2007.11868402>
- Passos, P., Araujo, D., & Volossovitch, A. (2017). *Performance analysis in team sports*. Routledge.
- R Development Core Team. (2011). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.r-project.org/>
- Ramos, A., Coutinho, P., Silva, P., Davids, K., Guimarães, E., & Mesquita, I. M. R. (2017). Entropy measures reveal collective tactical behaviours in volleyball teams: how variability and regularity in game actions influence competitive rankings and match status. *International Journal of Performance Analysis in Sport*, 17(6). <https://doi.org/10.1080/24748668.2017.1405611>
- Silva, M., Lacerda, D., & Joao, P. . (2013). Match analysis of discrimination skills according to the setter attack zone position in high level volleyball. *International Journal of Performance Analysis in Sport*, 13(2), 452–460.
- Sotiropoulos, K., Drikos, S., Papadopoulou, S. D., & Barzouka, K. (2020). Characterizing adaptations of serve indicators in top-level male volleyball among seasons. *International Journal of Sports Science and Coaching*. <https://doi.org/10.1177/1747954120978920>
- Stutzig, N., Zimmermann, B., Büsch, D., & Siebert, T. (2015). Analysis of game variables to predict scoring and performance levels in elite men's volleyball. *International Journal of Performance Analysis in Sport*, 15(3), 816–829. <https://doi.org/10.1080/24748668.2015.11868833>
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using Multivariate Statistics*. In *Pearson Education* (5th ed.). Pearson, Allyn and Bacon.
- Zeileis, A., Meyer, D., & Hornik, K. (2007). Residual-based shadings for visualizing (conditional) independence. *Journal of Computational and Graphical Statistics*, 16(3), 507–525. <https://doi.org/10.1198/106186007X237856>