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The influence of set speed on the attack efficacy of the outside hitter in elite male volleyball
La influencia de la velocidad de colocación en la efectividad del ataque del atacante receptor en voleibol

*Ricardo Franco Lima, **Catarina Morais, *Gonçalo Arezes, ***Rui Resende
*Instituto Politécnico de Viana do Castelo (Portugal), ** Universidade Católica Portuguesa (Portugal), ***Universidade da Maia (Portugal)

Abstract. The purpose of this study was twofold: a) to analyze if the set speed can predict the attack efficacy of the outside hitter; and b) if the team level is a predictor of set speed and attack efficacy. A total of 32 games of elite competitions were observed, and 260 attack actions performed by the outside hitters from six national teams were analyzed throughout the Kinovea Software. Independent-sample t-tests were conducted and, when differences between groups were significant (i.e., $p < .050$), those variables were included in the model as covariates. Additionally, to analyze the predictor variables of efficacy, logistic binary regression and linear regression were used. Results showed that the better the reception, the higher the set speed; however, neither the set speed nor the team level predict the attack efficacy. Thus, it can be concluded that the individual performance of the outside hitter should be developed instead the set speed. Notwithstanding, to increase the speed of the game, teams should improve the receptor efficacy. It is important for teams to find a set speed that balances the benefit of a faster set with the need for control and accuracy from the outside hitter.
Keywords: Volleyball; sports performance; kinovea software; side-out phase; game model.

Resumen. El propósito de este estudio fue doble: a) analizar si la velocidad establecida puede predecir la eficacia del ataque del atacante receptor; y b) si el nivel del equipo es un predictor de la velocidad establecida y la eficacia del ataque. Se observaron un total de 32 juegos de competiciones de élite, y se analizaron 260 acciones de ataque realizadas por los atacantes receptores de seis selecciones masculinas a lo largo del software Kinovea. Se realizaron pruebas t de muestras independientes y, cuando las diferencias entre grupos fueron significativas (es decir, $p < .050$), esas variables se incluyeron en el modelo como covariables. Además, se utilizaron regresiones binarias logísticas y regresiones lineales para probar los objetivos del estudio. Los resultados mostraron que cuanto mejor es la recepción, mayor es la velocidad de la jugada; sin embargo, ni la velocidad establecida ni el nivel del equipo predicen la eficacia del ataque. Por lo tanto, se puede concluir que el rendimiento individual del atacante receptor debería desarrollarse en lugar de la velocidad de la jugada. Sin embargo, para aumentar la velocidad del juego, los equipos deberían mejorar la eficacia de la recepción de los atacantes receptores. Es importante que los equipos encuentren una velocidad de la jugada que equilibre el beneficio de una jugada más rápida con la necesidad de control y precisión por parte del atacante receptor.
Palabras clave: Voleibol; rendimiento deportivo; software Kinovea; side-out fase; modelo de juego.

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Ricardo Franco Lima
ricardo.lima@esdl.ipvc.pt

Introduction

Volleyball stands as a widely embraced sport globally, characterized by its unique technical demands and physical requirements. Recent studies underscore advancements in technical skills, tactical options, and physical fitness among volleyball players (Drikos et al., 2022; García-de-Alcaraz et al., 2020; Guo, 2021; Lima et al., 2021).

Critical variables such as opponent strength, transition phase success, reception quality, and blocking efficacy have emerged as pivotal predictors of match outcomes (Drikos et al., 2022; Giatsis et al., 2022; Lima et al., 2019; Pena et al., 2013). Moreover, factors like serve-reception efficiency, attack effectiveness, and blocking proficiency are instrumental in determining match results (Patsiaouras & Kakaridas, 2019).

Knowing that, as demonstrated in the study from Martins et al. (2022) that analyzed inter-player variability within the same positional status in high-level men's volleyball through Social Network Analysis, there are variability between players of the same team and having the same positional status, the setter is the key player that should adapted himself to all of players variability (Martins et al., 2022).

Yet, setter's decision making could be changed by the game context in a flexible way and generate benefits for the attackers, namely in terms of number of opponent blockers (Costa et al., 2023). This advantage appears when setter is setting to position 3 and when the middle blocker is positioned close to the setter (Costa et al., 2023).

However, there remains a gap in understanding how team strategies and individual player profiles influence gameplay dynamics, particularly in relation to setter decisions and subsequent performance demands.

Of particular significance is the role of the outside hitter, a pivotal player tasked not only with precise passing but also with creating optimal set opportunities by the setter (Millán-Sánchez et al., 2017). This role demands exceptional reception skills to execute powerful attacks effectively (Costa et al., 2017). Conversely, poor reception may expose the outside hitter to difficulties measures regarding the attack efficacy (Araújo et al., 2010). Thus, research by Nikos et al. (2009) emphasizes the interdependence between setter and attacker performance, highlighting the setter's pivotal role in facilitating effective attacks.

While there is an understanding of the conditions contributing to a setter's success in volleyball, the correlation between the setter's distance from the outside hitter and the potential impact of set speed on attack efficacy remains largely unexplored. Investigating this relationship could

yield valuable insights into determining the optimal set speed based on the type of reception.

Thus, the purpose of this study leads us to analyze whether the set speed positively predicts the attack efficacy of the outside hitter, and the team level positively predicts set speed and attack efficacy.

Methods

Study Design

An observational and exploratory study was conducted. The video analysis was selected according to the relevance of the tournament. In this case, a total of 32 matches were observed during the World Championship 2022 (17 games), European Golden League 2022 (five games) and the qualifying for EuroVolley 2023 (10 games). All the selected competitions were chosen to allow us to ensure different competition levels within the data. We divided the players according to the ranking of the FIVB (2023). Thus, it was selected the outside hitters from four top 10 level teams, namely from Italy (3rd in FIVB ranking), France (8th in FIVB ranking), Japan (4th in FIVB ranking), and United States of America (2nd in FIVB ranking), while outside hitters from Portugal (22nd in FIVB ranking) and Turkey (14th in FIVB ranking) were chosen as the teams with lower level. A total of 260 independent attack actions (157 actions from the Top 10 teams and 103 actions from the other teams) were performed by the outside hitters from six different national teams. Coleman (2002) suggested that these software packages allow users to achieve intra-observer reliability values of 0.96-1.00 and in the case of this study the Kappa test.

A 10% of the sample (Tabachnick & Fidell, 2013) was randomly selected to calculate the reliability of the observations. The intra-observer Kappa values of all variables (Cohen, 1988) guaranteed the reliability, with all values being way above the minimum 0.75 (Fleiss et al., 2003) as shown in the table 1.

Table 1.
Intra-observer reliability.

Cohen's Kappa	Intra-Observer
Reception Type	0.952
Setting Zone	0.923
Attack Efficacy	0.990

Participants

For this study 24 elite volleyball players (26.24±4.17 years; 196.76±5.80 cm; 87.64±6.62 kg) were observed. 15 players belonged to the group of the best teams and 9 players to the other teams. The inclusion criteria used in this study focused on the type of reception, i.e., we only considered reception perfect (when the setter has perfect conditions to set the ball to all the attackers) or positive (when the setter has, at least, two attackers to set the ball), and the attacker should be the outside hitter in zone 4.

Instruments

To assess the attack actions from the outside hitters, Kinovea software was used. This software is a valid and reliable tool already used in recent studies that analyze the motion in volleyball (Forte et al., 2019; Sarpeshkar et al., 2017). Furthermore, the application of Kinovea Software goes beyond simple motion analysis. Notably, the Kinovea program was considered a valid and reliable tool that was able to measure accurately at distances up to 5 meters from the object (Puig-Diví et al., 2019). This experimental study endeavors to provide diverse insights within the team's playing model. To measure the set speed the formula distance/time was used (Mazo et al.,2022).

Procedures

Before importing the video into Kinovea software, we pre-process the footage using Data Volley, filtering it based on reception type and attack zone. The use of Data Volley is widespread among top volleyball teams for analyzing the performance of both their team and opponents (Lima et al., 2019). Specifically, for the setter's position preceding a set, the selection criteria include perfect receptions and positive receptions (see figure 4). All video recordings are consistently captured from behind the pitch to facilitate precise measurement of the distance between the setter and the outside hitter (see figure 1).

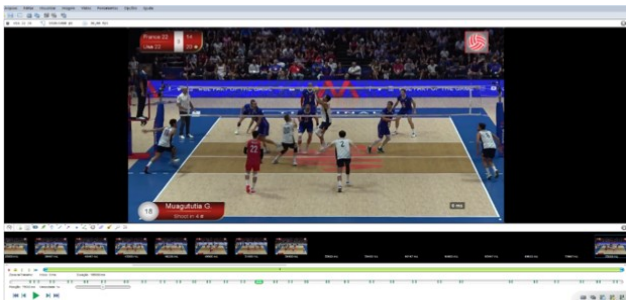

Figure 1. Observer visual field.

Upon each instance of the setter contacting the ball, we initiated the software's clock and recorded the ball's position (see figure 2). Subsequently, when the outside hitter executed the attack, the video was paused, and the distance between the set and the hit was precisely measured (see figure 3). Additionally, for assessing the reception quality, a grid of squares (1.5 meters x 1.5 meters), adapted from Afonso et al. (2012), was employed to provide information about the setting zone (see figure 4).

Figure 2. Moment where video was stopped when the setter touches the ball.

Figure 3. Moment where video was stopped when the outside hitter hit the ball.

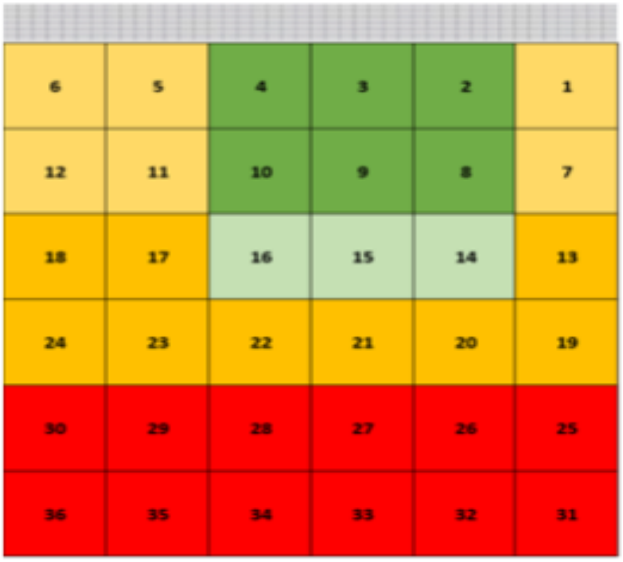

Figure 4. Setting zone according to the reception efficacy (green: perfect; yellow and dark yellow: positive; red: not considered).

Analysis

The analysis strategy consisted of three different sequential steps. First, in the preliminary analyses, we checked for normality and multicollinearity assumptions. Normality requirements are considered met if skewness values are in between -3 and 3, and kurtosis levels between -10 and 10 (Kline, 2011), Multicollinearity assumptions are met if Variance Inflation Factor (VIF) coefficients are below five. The second step consisted of defining which other variables of the study (not included in the hypotheses) could contribute to set speed and, therefore, should be controlled for (as covariates) in the regression model testing the relationship between set speed and attack efficacy. To do so, independent-sample t-tests were conducted and, when differences between groups were significant (i.e., $p < .050$), those variables were included in the model as covariates. The final step consisted of testing the hypotheses. Thus, logistic binary regression was used to test the idea that set speed and team level would predict attack efficacy, and linear regression conducted to test the assumption that team level would predict set speed. Statistical analyses were conducted using IBM SPSS Statistics (version 28, IBM, USA).

Results

Preliminary analyses

The first step consisted of testing the normality assumptions. All variables' skewness ($-0.62 > sk < 0.55$) and kurtosis ($0.39 > ku < 2.28$) were within the established parameters by Kline (2011; $sk < |3|$ and $ku < |10|$) and, therefore, no severe deviations from normality were found, and parametric tests were used. VIF coefficients were also checked to ensure that the multicollinearity assumptions were met. Indeed, all VIF coefficients were below 2.46 and, therefore, no indications of multicollinearity among predictor variables were found.

Considering the main hypothesis of the study (ball speed to predict the attack efficacy of the outside hitter), the second step aimed to define which covariates should be included in the regression model. Therefore, independent sample *t*-tests were conducted to check which variables could influence set speed and, consequently, should be isolated as covariates. Table 1 summarizes the results.

Table 2.
Summary of independent-sample t-tests using Set Speed as dependent variable.

Independent variable	T-test statistics	Interpretation
Type of serve (float *vs.* jump)	$t(257) = 1.66$, $p = .049$, $g = 0.23$	Set speed of the outside hitter is higher when opponents' serve is float (5.01±1.03m/s) when compared to jump serves (4.75±1.16m/s)
Attacking team (elite *vs* non-elite)	$t(257) = 1.40$, $p = .081$	Set speed of elite teams and non-elite teams is similar.
Opponent team (elite *vs* non-elite)	$t(257) = 2.12$, $p = .017$, $g = 0.30$	Set speed of the outside hitter is lower when facing elite opponents (4.74±1.13m/s) when compared to non-elite opponents (5.07±1.09m/s)
Outside Hitter Position (near *vs.* away)	$t(257) = 1.07$, $p = .143$	There are no differences on set speed considering the outside hitter position whether near or away from the setter.
Outside Hitter (receiver/non receiver)	$t(257) = 0.27$, $p = .395$	There are no differences on set speed based on whether the outside hitter was also the receiver of opponents' serve or not.
Reception (positive *vs.* perfect)	$t(257) = 2.62$, $p = .002$, $g = 0.33$	When serve reception is perfect, set speed is higher (5.04±0.68m/s) when compared to positive reception (4.67±1.34m/s)

In sum, t-tests revealed that type of serve, opponent and serve reception may be important variables to consider when analyzing set speed. Therefore, when testing the hypotheses, these variables were included as covariates.

Regarding the first aim of this study, whether the set speed positively predicts the attack efficacy of the outside-hitter, a binary logistic regression, including type of serve, opponent and serve reception as covariates, showed that set speed does not predict attack efficacy of the outside hitter, $b = -0.06$, $SE = .11$, $p = .588$. Only reception of serve emerges as a predictor variable [$b = 0.65$, $SE = .27$, $p = .015$], meaning that when reception is perfect (*vs.* positive), attack efficacy is 1.92 times higher to occur. As an exploratory analysis, we tested whether the relationship between

set speed and attack efficacy would be different depending on the attacking team's level. The results partially support this idea. Specifically, when attacking team is considered "elite team", serve type, reception, and set speed do not predict attack efficacy. However, when the attacking team is "non-elite", the serve reception (but not opponents' type of serve, neither set speed) predicts efficacy attack, b = 1.04, SE = .43, p = .015. Specifically, when the reception is perfect, it increases likelihood of efficacy by 2.84 times.

On the other hand, when analyzing whether the team level positively predicts set speed and attack efficacy, a linear regression was conducted to test the predictive value of team level on set speed, and a logistic regression to test its effect on the attack efficacy (both using type of serve, opponent and serve reception as covariates). The results from linear regression [$F(4,254) = 2.90$, $p = .022$, $R^2 = .04$ reveal that only quality of reception predicts set speed. Specifically, the better the reception, the higher the set speed ($b = 0.33$, $SE = .14$, $\beta = .15$, $t = 2.34$, $p = .020$). Thus, team's level did not predict set speed. A similar result was found for attack efficacy, as only quality of reception was found as significant predictor, b = 0.64, SE = .26, p = .016. Thus, when quality of reception is perfect, it increases the chance of the outside hitter attack to be efficient by 2.72 times.

Discussion

Knowing that, under suboptimal and optimal conditions, male setters set the ball to zone four, where outside hitter is often recruited (Sotiropoulos et al., 2018), the purpose of this study was to analyze whether the set speed could predict the attack efficacy of the outside hitter and the team level is predictor of set speed and attack efficacy.

Does set speed predict the attack efficacy of the outside hitter?

The study results showed that set speed does not predict attack efficacy of the outside hitter. However, the perfect reception emerges as a predictor variable, increasing the attack efficacy in 1.92 times.

These results are in line with previous literature demonstrating the importance of the performance in the reception action. For example, despite the set is considered one of the most important factors in volleyball because it could affect both the offensive and defensive systems of the team (Conti et al., 2016), the reception performance is associated with the increase of the attack efficacy (Conti et al., 2016; Lee & Chin, 2004; López et al., 2022; Mart et al., 2013; Silva et al., 2014); At this respect, in a recent study from González-Silva et al. (2020), which attempted to establish the relationship between service and reception with setting efficacy, showed that the reception efficacy and the setting zone determine the setting efficacy. Moreover, there has been an increase in the set speed (Marques Júnior, 2013), increasing difficulty in performing block action of the opponent. A faster set speed can be more difficult for the opposing team to defend against, and it can also give more options to the attacking team in terms of where and how they want to hit the ball. The previous factors prove the game pattern of the male volleyball teams which are increasing the aggressivity of the block actions and, to avoid those aggressivity, setters need to warrant the increase of the game speed, attempting to avoid well-formed blocks (Costa et al., 2012).

Additionally, a study from García-de-Alcaraz et al. (2016) is in line with our interpretation revealing that there has been a significant increase in block and defense for first and second tempo attacks, which matches with our results that demonstrated that the set speed should not be the main variable that predict efficacy.

Does team level predict set speed and efficacy of the outside hitter?

On the other hand, study results also showed that team's level did not predict set speed nor attack efficacy. Even though the hypothesis was not supported, they were consistent with Marcelino et al.'s (2011) findings: when analyzed the effect of the quality of opposition related to player roles and efficacy of game actions, they found that serve action as the technical action which could reveal differences in the team performance according to the team level. Furthermore, the serve efficacy determines the reception efficacy, so the study of the weak points of the reception of the opponent is one of the main factors to analyze (Papadimitriou et al., 2004).

Despite the valuable results, this paper has some limitations that should be referred, such as: (a) the set moment was not included in the analysis; (b) more teams should be analyzed; (c) the serve efficacy was not assessed; (d) players skills and physical characteristics were not assessed; (e) only the outside hitters were included in this study.

As a practical approach, the results of this study could give relevant data to coaches. Thus, to increase the speed of the game, teams should improve the reception efficacy of the outside hitters, independently if the outside hitter is near or away from the setter. In other hand, the jump serve should also be developed to decrease the speed game of the opposite and, consequently have more time to organize the block action of the own team. Finally, it's important for teams to find a set speed that balances the benefit of a faster set with the need for control and accuracy being necessary to adjust that balance throughout a match based on the performance of the team and their opponents.

Conclusion

When analyzed the type of serve, opponent and serve reception as covariates, the results showed that set speed does not predict attack efficacy of the outside hitter. Furthermore, only reception of serve emerges as a predictor variable, meaning that when reception is perfect (*vs.* positive), attack efficacy is 1.92 times higher to occur.

In the other hand, when attacking team is considered "elite team", serve type, reception, and set speed do not predict attack efficacy. However, when the attacking team is "non-elite", the serve reception (but not opponents' type of serve, neither set speed) predicts efficacy attack. Specifically, when the reception is perfect, it increases likelihood of efficacy by 2.84 times. Additionally, when quality of reception is perfect, it increases the chance of the outside hitter attack to be efficient by 2.72 times.

Despite the results, analysis demonstrated that type of serve, opponent and serve reception should be important variables to consider when analyzing set speed. These facts make us reflect on the relevance of the individual performance of the outside hitter that should be developed instead the set speed.

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Datos de los/as autores/as y traductor/a:

Ricardo Franco Lima	ricardo.lima@esdl.ipvc.pt	Autor/a
Catarina Morais	ctmorais@ucp.pt	Autor/a
Gonçalo Arezes	goncaloarezes99@gmail.com	Autor/a
Rui Resende	resende65@gmail.com	Autor/a
Carla Susana Gomes Correia da Silva	carlasugcsilva@gmail.com	Traductor/a