Original Article

The volleyball setter's decision-making on tipping in different game phases

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ABSTRACT

This study investigated how information emerging from interpersonal coordination affects the decision-making on tipping in different phases of the volleyball game. Eighty-six sequences of play involving tips performed by players of both sexes were selected from 20 games of a professional championship of volleyball (attack phase, n = 56; counterattack phase, n = 30). The following spatiotemporal measures of interpersonal coordination were calculated from the x and y coordinates of the player's positioning: area forming a gap between opponents, setter's displacement to the ball, setter's distances to the net and blockers, and passing velocity. A multivariate analyses of variance (MANOVAs) were run to compare the tips in the attack vs. counterattack phases, and traditional tips vs. non-traditional tips. The results revealed that the defending area and passing velocity were greater in attacking tips than in counterattacking tips. Setter's distance and velocity to reach the ball and the blockers were smaller in attacking tips than in the counterattacking ones. It was also revealed that the final distances between the setter and the net and him/her and the blockers were smaller in traditional tips than in non-traditional tips. It was concluded that the interpersonal coordination information based on which volleyball setter players make decisions on tipping differs between attacks and counterattacks, as well as traditional and non-traditional tipping. These findings provide a useful insight for practice tasks, since setters should be instructed to be perceptually attuned to their spatiotemporal relationship with defenders and ball in order to make decision on tipping.
Keywords: Performance analysis of sport, Volleyball, Team sport, Decision-making, Spatiotemporal interactions, Motor skill.

Cite this article as:
Denardi, R. A., Clavijo, F. A. R., De Oliveira, T. A. C., Ugrinowitsch, H., & Corrêa, U. C. (2023). The volleyball setter's decision-making on tipping in different game phases. *Journal of Human Sport and Exercise, in press.* https://doi.org/10.14198/jhse.2023.183.17

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Submitted for publication March 03, 2023.
Accepted for publication March 23, 2023.
Published *in press* April 18, 2023.
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.183.17

INTRODUCTION

Over the last few years, the spatiotemporal information emerging from players cooperation and opposition have increasingly been recognized as a key aspect of successful decision-making in team sports (Davids et al., 2020; Denardi et al., 2016; Passos et al., 2014, 2016; Vilar et al., 2012). For instance, research findings have shown that players make decisions based on perception of critical values of interpersonal distance and relative velocity (e.g. Passos et al., 2008), defensive area (e.g. Corrêa et al., 2014), attacker-defender temporal synchronization (e.g. Correia et al., 2016), and attacker-teammate-defender's relative angle (e.g. Pinho et al., 2021), which represent physical measures of interpersonal coordination that afford gaps or opportunities for action.

Notwithstanding the advancements provided by the foregoing studies, most of them have been developed seeking to understand the decision-making of motor skills performed in team sports of invasion, that is, sports in which the aim is to invade an opponent's territory (e.g., field, pitch, or court) and score a goal or point (Clavijo et al., 2018). Recently, studies began to be developed by considering interpersonal coordination in non-invasive team sports. This is the case of net sports such as volleyball (Afonso & Mesquita, 2011; Barsingerhorn et al., 2013; Denardi et al., 2017a/b, 2018, 2019; Paulo et al., 2018; Rocha et al., 2020). For instance, a study by Denardi et al. (2017a) investigated the volleyball setter’s decision-making on tipping. This refers to a setters’ exceptional action that comprises only 2% of their actions (Palao et al., 2007). The tipping involves a high level of unpredictability since the setters suddenly changes the action of setting the ball to a teammate to action of tipping. This study revealed that setters make decisions on tipping based on the size of the area (gap) formed by the defenders. In this case, the larger the area, the greater the possibility that the tip to be successfully completed. It was also verified that the rates of displacement (velocity) of the ball, setter, and blockers also function as an informational variable for such decision-making. These findings provided useful insights for practice tasks since players could be instructed to position near the net and to be attuned to the gap formed by the defenders' positioning, as well as the ball displacement characteristics (distance and speed).

The present study sought to extend the knowledge about volleyball setters’ decision-making by considering they play a critical role on the organization of the attack (Palao et al., 2004, 2005). The game of volleyball unfolds in phases of attacking and defending. When this latter is successful, it results in counterattacking. Therefore, attack and counterattack represent sequential phases of ball possession transition (Castro et al., 2011;Eom& Schutz, 1992; Hileno et al., 2020; Ugrinowitsch et al., 2014). Moreover, in these phases the setters can tip in a traditional and non-traditional way representing choice alternatives for decision-making (Bezault, 2002; Lavega, 2002). In the traditional tip, one hand is removed when the ball is near both hands, and the ball is touched with a movement from top to bottom. On the other hand, the non-traditional tips use one or both hands through bottom-up movements. Therefore, this study sought to understand how interpersonal coordination information affects the setters’ decision-making on the type of tipping in different phases of the volleyball game.

METHODS

Sample

The sample consisted of 86 sequences of play from 20 volleyball games of the 40th edition of the male and female’s Paulista Championship 2013-Division I. This is one of the largest Brazilian professional championships of volleyball, held in São Paulo state, in which approximately 6 male and 10 female teams (approximately 190 players) participated. The sequences of play involving tips performed by the setters (*males*, n = 43; *females,* n = 43) were selected according to their emergence over the volleyball games (*attack phase*, n = 56; *counterattack phase*, n = 30). All setter tips were included, regardless of the team or if they occurred in the same rally. Participation required the volunteers' written consent, and the experimental protocol was given ethical approval by the local Institutional Review Board.

Data collection

The sequences of play were selected from the digital video footage of the aforementioned games. They were recorded by a digital camera (Casio HS EX-FH100) located above and behind the volleyball court. The images were captured at a frequency of 30 Hz and afte4r adjusted to 25 Hz using Video Converter Factory software. The displacements of all the players were edited through TACTO software (Duarte et al., 2010; Fernandes et al., 2010) from the moment the receiver touched the ball (initial moment "*I*") to the moment the setter touched the ball (final moment "*F*"). The receiver was defined as the player who touched the ball before the setter. This procedure consisted of following the players' working point (projection of the centre of gravity of each individual player on the floor) in a slow-motion video image (frequency = 2 Hz) using a computer mouse.

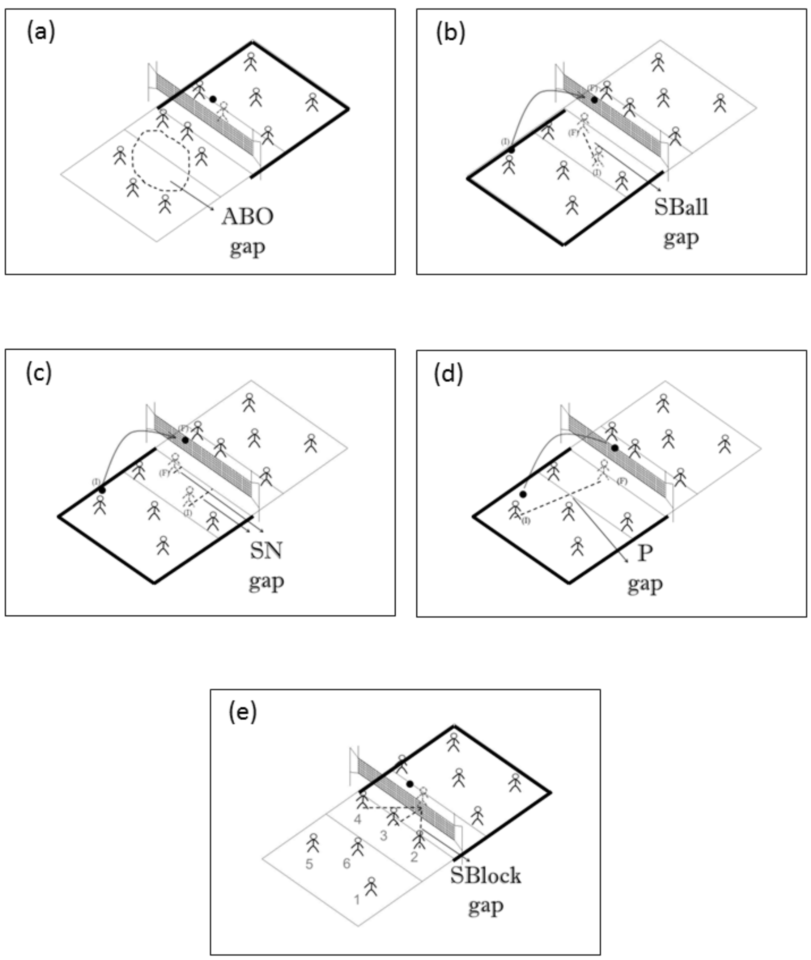

Figure 1. Illustration of: (a) area between opponents in the final moment of the sequence of play; (b) displacement of the setter to the ball; (c) distances between the setter and net in the initial (I) and final (F) moments of the sequence; (d) passing velocity; (e) Distances between the setter and the three possible blockers (i.e., 2, 3, and 4 positions) in the final moments of the sequence of play.

This procedure allowed acquiring of the virtual *x* and *y* coordinates of each displacement trajectory (i.e., in pixels). After that, these coordinates were transformed into real coordinates by direct linear transformation (DLT2D) software and filtered with a low-pass filter (6 Hz) (Winter, 2005). This method considers the *z* coordinates to be equal to zero and directly correlates an object point located in the object space/plane with a corresponding image point on the image plane (Duarte et al., 2010; Fernandes et al., 2010).

Data analysis

The player's *x* and *y* coordinates of displacement and the calibration references were inserted into MATLAB software (version 2013a). These procedures allowed the calculation of the following measures of interpersonal coordination that have been characterized as informational variables constraining setters' decision-making (Denard et al., 2017a) (Figure 1).

(a) ABO - Area between opponents in the final moment of the sequence of play (Figure 1a). This was calculated by the equation:

$$A = \left|(x_1 y_2 - y_1 x_2) + (x_2 y_3 - y_2 x_3) \ldots\ldots + (x_n y_1 - y_n x_1) / 2\right|$$

where x and y refer to the coordinates of each player specified by the superscript number.

(b) dSBal l- Displacement of the setter to the ball (Figure 1b). It was calculated by the equation:

$$d = \sqrt[2]{(SI_x - SF_x)^2 + (SI_y - SF_y)^2},$$

where d refers to the distance between the setter position in the initial (SI) and final (SF) moments of the sequence of play. In addition, the setter's velocity of displacement (vSball) was calculated through:

v = [d/t],

where v is the velocity, d is the distance value obtained above, and t refers to the time of displacement.

(c) dSN - Distances between the setter and net in the initial (I) and final (F) moments of the sequence (Figure 1c). This was calculated by the equation:

$$d = \sqrt[2]{(S_x - N_x)^2 + (S_y - N_y)^2},$$

where d refers to the distance between the setter (S) and net (N), according to the x and y axes.

(d) vP - Velocity of the ball from digger to setter (passing velocity) (Figure 1d). This was calculated by the equation:

v = [d/t],

where v is the velocity, d refers to the distance between digger (D) and setter (S), according to the x-and y-axes, calculated through:

$$d = \sqrt[2]{(D_x - S_x)^2 + (D_y - S_y)^2}$$

and t refers to the time of displacement.

(e) Sblocks 1, 2 and 3 - Distances between the setter and the three possible blockers (i.e., 2, 3, and 4 positions)in the final moments of the sequence of play (Figure 1e). It was calculated by the equation:

$$d = \sqrt[2]{(S_x - B_x)^2 + (S_y - B_y)^2},$$

where d refers to the distance between the setter (S) and blocker (B), according to the x and y axes.

Statistical procedures

First, a multivariate analysis of variance (MANOVA) was run to compare tips in the attack vs. counterattack phases by considering nine dependent variables (ABO, SBall, vSball, dSN-I, dSN-F, vP, SBlock-1, SBlock-2, and SBlock-3). Second, a MANOVA was conducted to analyse the tipping patterns by comparing 52 traditional tips vs. 34 non-traditional tips. In all analyses, observed significant effects were followed up using univariate analysis (ANOVAs) with Bonferroni correction. For all analyses, the level of significance was set at $p < .05$ using SPSS software version 21.0.

RESULTS

Game phases

The results showed significant effects for phase (attack vs. counterattack) [Wilks' Lambda = 0.55, $F(9,76) = 6.95$, $p = .00$, $\eta p^2 = 0.452$]. The univariate analyses revealed effects for ABO [$F(1,84) = 10.24$, $p = .00$, $\eta p^2 = 0.109$], dSBall [$F(1,84) = 7.24$, $p = .00$, $\eta p^2 = 0.079$], vSBall [$F(1,84) = 6.38$, $p = .01$, $\eta p^2 = 0.071$], vP [$F(1,84) = 20.15$, $p = .00$, $\eta p^2 = 0.193$], and SBlock-4 [$F(1,84) = 4.52$, $p = .04$, $\eta p^2 = 0.051$].

It was verified that tips in the attack phase had greater ABO (M = 21.8 m^2) than during the counterattack phase (M = 18.7 m^2) (Figure 2A); *dSBall* was smaller in attacking tips (M = 0.96 m) than in counterattacking tips (M = 1.49 m) (Figure 2B), and *vSBall* was also smaller in attacking tips (M = 0.7 m/s) than in counterattacking tips (M = 1 m/s) (Figure 2C); *vP* was greater in attacking tips (M = 3.8 m/s) than in counterattacking tips (M = 2.9 m/s) (Figure 2D); *SBlock-4* was smaller in attacking tips (M = 1.47 m)than in counterattacking tips (M = 1.82 m) (Figure 2E).

Tip pattern

The results showed significant effects for pattern (traditional vs. non-traditional) [Wilks' Lambda = 0.69, $F(9,76) = 3.74$, $p = .00$, $\eta p^2 = 0.307$]. The univariate analyses revealed effects for dSN-F [$F(1,84) = 19.34$, $p = .00$, $\eta p^2 = 0.187$], SBlock-2 [$F(1,84) = 4.52$, $p = .04$, $\eta p^2 = 0.051$], SBlock-3 [$F(1,84) = 14.09$, $p = .00$, $\eta p^2 = 0.144$], and SBlock-4 [$F(1,84) = 4.20$, $p = .04$, $\eta p^2 = 0.048$].

It was verified that *dSN-F* was smaller in traditional tips (M = 0.45 m) than in non-traditional tips (M = 0.84 m) (Figure 3A), and *SBlock-2*, *SBlock-3,* and *SBlock-4* were smaller in traditional tips than in non-traditional tips (M = 3.78;4.28 m, M = 1.62;2.27 m and M = 1.46;1.80 m, respectively) (Figure 3B, C and D).

In both analyses, some variables showed significance at $p < .05$: dSN-F in the first one and dSBall, vSBall, dSN-I, and vP in the second one. However, these results were not considered because the homogeneity of variance could not be assumed from the Levene test. In this case, it is suggested to consider results at the below level, as $p < .001$.

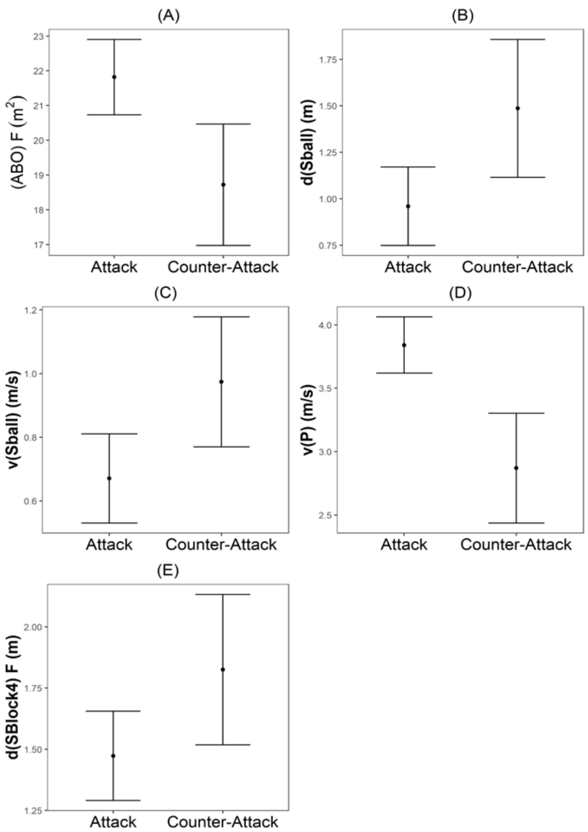

Figure 2. Mean values of (A)ABO, (B) dSBall, (C) vSBall, (D) vP, and (E) SBlock-4, in attacking and counterattacking tips.

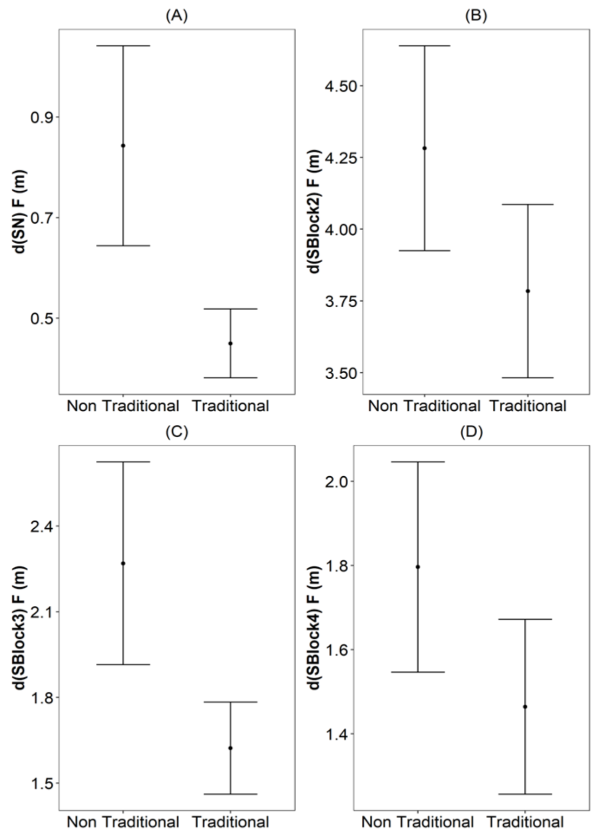

Figure 3. Mean values of (A)ABO, (B) dSBall, (C) vSBall, (D) vP, and (E) SBlock-4, in attacking and counterattacking tips.

DISCUSSION

From a systemic point of view, team sports function based the interplay of negative and positive feedback mechanisms. That is, while defending team works based on a deviation reduction mechanism (negative feedback) between it and the attacking team, the latter works to amplify or create discrepancies (positive feedback mechanism) (Corrêa et al., 2020, 2021). Perhaps this latter is the setter case who may have made the decision on tipping in order to break the defensive team's atonements with its team through a surprising action.

The aim of this study was to investigate the volleyball setter's decision-making on the type of tipping in different volleyball game phases based on spatiotemporal variables of interpersonal coordination. The results revealed that the defending area and passing velocity were greater in attacking tips than in counterattacking tips. Setter's distance and velocity to the ball and blockers were smaller in attacking tips than in the counterattacking ones. Regarding the type of tipping, it was verified that the final distances between the setter and net and blockers were smaller in traditional tips than in non-traditional tips.

The attack phase is considered more organized than the counterattack one, since at the moment the rally starts, the receivers can predict the ball travelling characteristics in terms of temporal rate and direction (Denardi et al., 2017b; Eom & Schutz, 1992; Lee, 2010). Consequently, the setter has more availability to consider the complexity of interpersonal information emerging from players' dynamic interaction, as well as position him/herself to receive a pass. This scenario may have provided more opportunities for tipping performances, since they occurred more frequently in the attack phase. In contrast, the counterattack phase is characterized by reorganization because players are repositioning themselves after the first attack, which results in a shorter time to organize the block and defence than in the attack phase (Eom & Schutz, 1992). These conditions should lead the setter to have higher distances and move faster than in the attack phase. According to Matias and Greco (2011), during counterattack phases the setters mostly receive passes in poor conditions (zone, height, and velocity) to perform their actions.

Curiously, although the small final distances between the setter and net may indicate highly accurate passes in the attach phase, which means the best conditions for decision-making on tipping, there were large defence areas, may have made tipping difficult. In fact, the attack phase had the lowest percentage of defence trials compared to the counterattack phase. Specifically, there were defence trials in 55% and 63% of the tips in the attack phase and counterattack phase, respectively. Since the middle player attack affects the attack phase rally definition because it is too fast for defence reaction (Cota et al., 2016), players should use this information and prioritize the defence of spiking instead of the tip by increasing the defensive area.

The greater defensive area in the attack phase may occur because the players change positions during the served ball displacement, as well as the server's displacement to its functional position. According to volleyball rules, at the time of service each player must occupy one of the six zones of the volleyball's half court. In addition, they have to rotate clockwise by one zone when they win a rally that the opponent team served. Nevertheless, players perform specialized functions in the team (e.g., setter, outside hitter, opposite, middle player, and libero), which usually starts by changing their positioning from the serve (Laios & Kountouris, 2010; Millán-Sánchez et al., 2019). On the other hand, a smaller defensive area in the counterattack phase may have occurred because the team had already organized itself spatially with respect to the roles of the players. Additionally, it could be hypothesized that the fact that the pass was fast may have reduced the time for the defence to decrease its area in the attacking phase and, therefore, cover more of its gaps.

Regarding the traditional and non-traditional tips, the fact the setter was close to the net and blockers probably provided an angle of attacking that made it possible to tip the ball in a top-down way, that is, a traditional tip. In contrast, if he/she did it from the long foregoing distances, the ball would hit the net or the blockers. Therefore, in this condition the most appropriate tip would be that non-traditional (button-up). Thus, it is possible that the setter has perceived the different affordances provided for these emerging conditions of interpersonal coordination and, consequently, made decisions constrained by them (Denardi et al., 2017a, 2018).

CONCLUSIONS

In summary, the findings of this study allow us to conclude that the interpersonal coordination information (defending area, passing velocity, setter's distance and velocity to the ball and to blockers) constrained the volleyball setter decision-making on tipping in the attack and counterattack phases of the game. In addition, decision-making on the types of tipping was affected by the final distance between the setter to the net and the blockers. These conclusions are closely related to the methods and findings of the present study; consequently, at least they need to be replicated to achieve the necessary consistency for generalization. Therefore, with due caution, one could say these findings provide a useful insight for practice tasks, since setters should be instructed to be perceptually attuned to their spatiotemporal relationship with defenders and ball in order to make decision on tipping. Further studies should include the *z*-axis in their analyses since it refers to an important dimension of volleyball players' movement displacement.

AUTHOR CONTRIBUTIONS

Renata Alvares Denardi contributed to the research design, data collection and article writing. Umberto Cesar Corrêa contributed to the research design and article writing. Fabian Alberto Romero Clavijo and Thiago Augusto Costa de Oliveira contributed to the data collection and analysis. Herbert Ugrinowitsch provided critical revision and contributed to the critical article writing.

SUPPORTING AGENCIES

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001.

DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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