Is there a setting distribution pattern in high-level men's volleyball? An ecological approach to the game.

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Published online: July 31, 2021

(Accepted for publication July 15, 2021)

DOI:10.7752/jpes.2021.s3279

Abstract:

The investigation of the perception of affordances in sport has evolved by considering an ecological analysis of the game, thus seeking to understand how athletes collect information from the environment to increase the chances of making appropriate decisions concerning the constraints of the game. Perception of affordances involves an interaction of intentions, perceptions, and actions in specific contexts. During a volleyball match, the setters must have the perception of affordances quickly, depending on the situational constraints involving the position of the central attackers and blockers. Thus, this study aimed to identify whether the distance between the setter and the central attacker and between the setter and the opposing central blocker is a constraint to identify affordances and consequent distribution patterns for high-level setters. For this purpose, 93 side-out actions were selected under optimal setting conditions, which allowed an organized attack with all attack options from the two final matches of the Men's World Club Championship 2015 and 2016. One-way ANOVAs were performed to identify differences in the distances of the x and y axes in meters. These distances were analyzed according to the setting zone, set outcome, and different blocks of scores during the sets. No significant differences were found between the distances of the central blocker and the central attacker concerning the setter according to setting zones, the outcome of the sets, and scoring blocks throughout sets. Therefore, the constraints of the game revealed high variability and unpredictable behaviors in the setters' actions, preventing the identification of setting distribution patterns.

Key Words: Ecological analysis, game analysis, perception-action, perception of affordances, first attack tempo

Introduction

Perception of affordances is a process in which athletes choose a technique and seek an appropriate tactical solution in response to their current game situation (Raab, 2007). That is, athletes plan future actions and tactical based on environmental information determined by the specificity of the game context (MacMahon and MacPherson, 2009; García-González et al., 2011). Accordingly, many studies have sought to understand the perception of affordances process in sport (Bar-Eli and Raab, 2006; Corrêa et al., 2020; Conejero Suárez et al., 2020). However, the ecological analysis of the game is a recent topic of interest in this research field (Woods et al., 2020a).

Considering the ecological nature of the game at the time of performing perception of affordances is imperative since the sport is regarded as a dynamic system in which the subject, the environment, and the task are in constant interaction. This demands from athletes the timely identification of the constraints of action possibilities, i.e., the affordances (Jacobs and Michaels, 2007; Araújo et al., 2019 Woods et al., 2020a, b). In light of this, athletes use perception-action mechanisms to collect meaningful information from the environment to act appropriately in the face of the demands imposed by the game (Araújo and Davids, 2009). Based on these characteristics, the behavior is considered a self-organized phenomenon that emerges from the continuous and dynamic interaction of the individual's possibilities of perception of affordances, based on his characteristics and according to the environment (Araújo et al., 2006). Following this framework, athletes' skilled behavior emerges from solutions to the environment, considering the desired performance (Araújo et al., 2020).

The desired skilled performance reaches from the interaction with the changeable environment (Araújo et al., 2020; Woods et al., 2020b), whose specific characteristics can act as an attractor conducting stable behavior. Moreover, continuous practice increases the number of interactions, and the athletes gain more information, resulting in more attractors. More attractors can drive the coexistence of different stable behaviors, characterizing multistable stability (Kelso, 2012), when the perception of affordances can move between different modes of action (Araújo et al., 2019), and multiple stable behaviors can be selected (Araújo et al., 2020).

When considering volleyball, the environment has influenced different actions such as reception (Paulo, Davids, & Araujo, 2018; Araújo et al., 2020), setting (Denardi et al., 2017; Rocha et al., 2020), spiking (Sarvestan et al., 2020; Rocha et al., 2019b), attack coverage (Laporta et al., 2015), among other aspects of the game (Hurst et al., 2017; Laporta et al., 2018; Přidal, Toporová, & Priklerová, 2021). However, it is observed that the setting occurs at a critical moment, since it is only from that moment on that it is possible to introduce variability in the offensive phase (Ramos et al., 2017), making it the main point to the attack organization (Palao et al., 2004; 2005). In such a way, the setter's performance, whether from the attack or defense zone, modifies the type of game played by the team (Silva et al., 2013; 2014).

Most research that investigated the setting have sought to understand what is the relationship between the setting conditions and the perception of affordances of the setter (Costa et al., 2016a; Ramos et al., 2017), as well as to find distribution patterns based on variables inherent to the organization of the defensive system (Afonso et al., 2010; Rocha et al., 2020). Overall, higher-level teams show greater variability in attack actions, such as attacking zones and tempos (Ramos et al., 2017a). For example, attack tempo is characterized by the gap in time between the set and the spike, first proposed by Afonso, Marcelino, Mesquita and Silva (2010). Later, Costa et al. (2017) adapted the Afonso et al (2010) proposal in three classes: first, second, and third attack tempos. Furthermore, the relation between tempo and attack zone has been used to analyze different effects of volleyball attack (Ramos et al., 2017b). Accordingly, high-level teams show greater frequencies of optimal setting conditions (i.e., all available attackers), the use of faster attack tempos, and the number of attacks in zone 3 (central and front zone of the court) (Ramos et al., 2017b), the place with the fastest attack time, the 1st attack tempo (Costa et al., 2016b).

Although the literature indicates that actions depend on the perception of affordances of ecological variables of the game, such as the initial distribution conditions, opposing blockers and attack times (Ramos et al., 2017a, b; Rocha et al., 2020), other constraints have not been investigated yet. For example, constraints in the playing environment, such as the distance from the setter to attackers and opponent blockers, can result in different affordances and change the distribution pattern of high-level setters. Therefore, we aimed to investigate if the constraints distance from the setter to the central attacker and the opposing central blocker influence affordance perception and change the distribution pattern in high-level setters according to the setting zone, the outcome of the set, and moments of the set (0 to 10 points, 11 to 20 points and 21 points until the end of the game). The present study hypothesizes that no patterns will be found in the setting distribution of high-performance setters as a result of the variability in setter pattern.

Material & methods

Study Design and Setting

This study followed an observational analytic cross-sectional design. The two final games of the Volleyball World Club Championship of the years 2015 and 2016, played between the male teams of Sada Cruzeiro (Brazil) and Zenit Kazan (Russia) were analyzed. The results of the games were 3 x 1 (2015) and 3 x 0 (2016) with Sada Cruzeiro's team champion on both occasions. The partials of the sets were 25x21; 21x25; 27x25; 25x21 and 25x21; 25x23; 25x15, respectively.

The 2015 Men's Volleyball World Club Championship (11th edition) was played between October 27th and 31st, in the city of Betim/Brazil with six teams participating in this championship. The 2016 Championship (12th edition) was held between the 18th and 23rd of October, in the same city, with eight teams participating. The staff of the Sada Cruzeiro volleyball team provided the data analyzed in this study in October 2018.

Participants

The sample consisted of three setters from Sada Cruzeiro (Brazil) and Zenit Kazan (Russia), being one from the Brazilian team and two from the Russian team. A total of 93 game sequences were analyzed according to an eligibility criterion based on the quality of the reception. Only actions that represented optimal setting conditions (i.e., located inside the attack zone and in zone 3 of the volleyball court, allowing the central attackers to spike fastballs) were selected (see Rocha et al., 2021; Rocha et al., 2019). This research was performed following the ethical standards established in the Declaration of Helsinki of 1964, amended in 1989. According to the policy of the local University, this type of data collection does not require approval from an Institutional Review Board.

Materials

Game sequences were recorded using a Sony® Hdr-CX405 HD camera that was positioned above and behind the volleyball court. This device has a Full HD 1920x1080 video capture at 60 fps and stored footage in .avi format. Videos were processed using the TRACKER® software (version 5.0.5), a video analysis and modeling tool, in which position and time data were obtained.

The TRACKER® software, a two-dimensional analysis system, was configured using the nine-meter metric established by the distance between the two antennas at the top of the edge of the net. Circular markers were plotted on the head of the opponent's central blocker and on the head of the central attacker, since this type of marker has greater software accuracy for the position axes. The moment used to insert the markers was in the last frame before the ball was released from the setter's hand (as shown in Figure 1). Therefore, the last frame in which the ball was still in the setter's hand was used as a reference to identify the distance in all videos of the analysis of the position and time data on the x and y axes. The data analyzed were: the distance between the setter and the opposing central blocker in the x and y axes in meters, the distance between the setter and the central attacker in the x-axis in meters, distance between the central attacker and the central blocker in the x-axis, in meters, and the zone where the setter performed the setting (e.g., position 4, 3, 2, 1 or 6).

Figure 1. Data collection using the TRACKER® software.

The reliability analysis indicated an inter-observer rate of 0.99 and an intra-observer rate of 0.98. The sequences analysis were carried out at two different times. The first evaluation was performed in a single day and the second evaluation was performed two weeks later. Forty images out of 99 were chosen randomly for the reliability analysis, which comprises more than 10% of the total, as suggested in the literature (Tabachnick and Fidell, 2013). Two professionals with 10 years' experience as volleyball coaches (e.g., international level with the base categories of the Brazilian National Teams and American College level) selected the sequences that met the criteria specified in this study.

Statistical Analysis

The analysis of the distance data was performed using descriptive statistics (mean and standard deviation). The Shapiro-Wilk and Levene tests were performed to verify the normality of data and homoscedasticity of data variances, respectively ($p > 0.05$). A one-way ANOVA was performed to investigate differences in the distances between the setter and the central blockers and between the setter and the central attacker. Another one-way ANOVA was performed to investigate differences in the aforementioned distances in winning and losing sets. Finally, a one-way ANOVA was performed to investigate differences in the same distances in three scoring blocks of the games (block 1 = 1 to 10 points; block 2 = 11 to 20; block 3 = 21 until the end of the set). The level of significance was 5%. The effect sizes (η_p^2) were calculated and interpreted as follows: small for $\eta_p^2 > .01$, medium for $\eta_p^2 > .09$ and large for $\eta_p^2 > .25$ (Cohen, 1988). The statistical package Statistica® 12.0 was used for data treatment and analysis.

Results

The assumptions of normality and homogeneity of data were confirmed. Table 1 shows a descriptive analysis of the distance between the setter and the attacker (central attacker distance on the X-axis) and between the setter and the central blocker (central blocker distance on the X-axis and the Y-axis), indicated similar values

when analyzing the general context (as described in Table 1), the attack zone (as described in Table 2), the sets won and lost (as described in Table 3), and the moment of the game (as described in Table 4).

Table 1. Mean and standard deviation of the distances (m) between setters, central blockers and central attackers on the X and Y axes.

Distances (m)	Mean	±	Standard Deviation
X-Axis Central Blocker	4.53	±	0.79
Y-Axis Central Blocker	2.17	±	0.14
X-Axis Central Attacker	4.53	±	1.53
X-Axis Central Blocker – Central Attacker	0.00	±	1.05

Table 2 shows the distance between the central blocker and central attacker in relation to the setting zone. The one-way ANOVA used to identify differences in the distances of the central blocker and the central attacker in relation to the setter according to setting zones did not show differences between setting zones [$F(9,211.89) = 0.839$, $p = 0.58$, $\eta_p^2 = 0.034$].

Table 2. Distances of the central blocker and the central attacker in relation to the setter according to setting zones.

		95 % CI			
Distances (m)		Mean	Standard Error	Lower	Upper
Zone 2 (N=17)	X Central Blocker (Bx)	4.53	0.19	4.15	4.91
	X Central Attacker (Ax)	4.64	0.37	3.89	5.38
	X Difference (Bx) – (Ax)	-0.10	0.25	-0.61	0.40
	Y Central Blocker (By)	2.16	0.03	2.09	2.23
Zone 3 (N=48)	X Central Blocker (Bx)	4.45	0.11	4.22	4.68
	X Central Attacker (Ax)	4.44	0.22	4.00	4.89
	X Difference (Bx) – (Ax)	0.01	0.15	-0.29	0.31
	Y Central Blocker (By)	2.17	0.02	2.13	2.21
Zone 4 (N=13)	X Central Blocker (Bx)	4.75	0.22	4.31	5.19
	X Central Attacker (Ax)	4.43	0.43	3.58	5.29
	X Difference (Bx) – (Ax)	0.31	0.29	-0.26	0.89
	Y Central Blocker (By)	2.13	0.03	2.05	2.21
Zone 6 (N=15)	X Central Blocker (Bx)	4.56	0.20	4.15	4.96
	X Central Attacker (Ax)	4.73	0.40	3.93	5.53
	X Difference (Bx) – (Ax)	-0.17	0.27	-0.71	0.36
	Y Central Blocker (By)	2.20	0.03	2.13	2.28

Note. 95% CI – 95% confidence interval; (Bx) – Central Blocker distance on the X-axis; (Ax) – Central Attacker distance on the X-axis; (By) – Central Blocker distance on the Y-axis.

Table 3 shows the distance between the central blocker and central attacker in relation to the sets won and lost. The one-way ANOVA used to identify differences in the distances of the central blocker and the central attacker in relation to the setter according to the outcome of the sets did not show differences between winning and losing sets [$F(3,89) = 1.277$, $p = 0.28$, $\eta_p^2 = 0.041$].

Table 3. Distances of the central blocker and the central attacker in relation to the setter according to the outcome of the sets.

	Distances (m)	Mean	Standard Error	95 % CI	
				Lower	Upper
Sets Won (N=49)	X Central Blocker (Bx)	4.52	0.11	4.29	4.74
	X Central Attacker (Ax)	4.61	0.21	4.18	5.03
	X Difference (Bx) – (Ax)	-0.09	0.15	-0.39	0.20
	Y Central Blocker (By)	2.15	0.01	2.11	2.18
Sets Losses (N=44)	X Central Blocker (Bx)	4.53	0.11	4.30	4.77
	X Central Attacker (Ax)	4.42	0.23	3.96	4.88
	X Difference (Bx) – (Ax)	0.11	0.15	-0.20	0.42
	Y Central Blocker (By)	2.20	0.02	2.16	2.24

Note. 95% CI – 95% confidence interval; (Bx) – Central Blocker distance on the X-axis; (Ax) – Central Attacker distance on the X-axis; (By) – Central Blocker distance on the Y-axis.

Table 4 shows the distance between the central blocker and central attacker in relation to the moment of the game. The one-way ANOVA used to identify differences in the distances of the central blocker and the central attacker in relation to the setter according to the three scoring blocks of the game sets also failed to show differences between game blocks [$F(6,176) = 1.2196$, $p = 0.29$, $\eta_p^2 = 0.039$].

Table 4. Distances of the central blocker and the central attacker in relation to the setter according to scoring blocks throughout sets.

	Distances (m)	Mean	Standard Error	95 % CI	
				Lower	Upper
Scores 1 to 10 (N=44)	X Central Blocker (Bx)	4.63	0.11	4.39	4.87
	X Central Attacker (Ax)	4.66	0.22	4.20	5.11
	X Difference (Bx) – (Ax)	-0.02	0.15	-0.33	0.28
	Y Central Blocker (By)	2.16	0.02	2.11	2.20
Scores 11 to 20 (N=39)	X Central Blocker (Bx)	4.47	0.12	4.22	4.72
	X Central Attacker (Ax)	4.60	0.24	4.12	5.08
	X Difference (Bx) – (Ax)	-0.13	0.16	-0.46	0.19
	Y Central Blocker (By)	2.18	0.02	2.14	2.23
Scores 21 to 27 (N=10)	X Central Blocker (Bx)	4.28	0.24	3.78	4.77
	X Central Attacker (Ax)	3.62	0.47	2.67	4.57
	X Difference (Bx) – (Ax)	0.65	0.32	0.01	1.30
	Y Central Blocker (By)	2.17	0.04	2.09	2.26

Note. 95% CI – 95% confidence interval; (Bx) – Central Blocker distance on the X-axis; (Ax) – Central Attacker distance on the X-axis; (By) – Central Blocker distance on the Y-axis.

Discussion

The aim of our study was to investigate whether the distance between the setter and the central attacker and the setter and the opposing central blocker would indicate a distribution pattern in high-performance setters under optimal setting conditions. Moreover, we sought to investigate whether the attacking zone, the outcome of set, or the moment of the set would affect the distribution pattern. The results showed that there were no differences in any of the environmental constraints considered, suggesting that the setter affordance perception was highly fluctuating in this game context. These results are in line with the study by Ramos et al. (2017a) that indicated that female elite setters are more skilled and show more refined levels of collective organization. That is, these athletes' performance behaviors were based on collective and coherent variability in setter pattern,

making difficult to the block to identify affordance in the set-attack interaction. These evidences are supported by the ecological dynamics framework, since human behavior (in this case sports behavior) is based on paradigms of self-organization, emergence, synergy, non-linearity and non-proportionality, coupling the relationship between information movement and possibilities of action (Seifert et al., 2017). The ecological dynamics and the information-movement coupling in sports performance proposes that the athlete's behaviors and interactions in a competitive performance environment are regulated by the information available (i.e., quality of the actions of his own team, availability of attackers, movements of opposing players, positioning of blockers, among others). These, in turn, specify the athlete's actions in contexts of competitive sports performance, without postulating internal control structures (Seifert et al., 2017; Araújo and Davids, 2018). In this context, the athlete's perception of feasible actions towards the goal change at every moment of the game, bringing forth environments with high variation in the perception of affordances processes (Davids and Araújo, 2010; Araújo and Davids, 2018).

On the other hand, our results are not in line with the findings of Ramos et al. (2017b), Rocha et al. (2020) and Rocha et al. (2021), since these studies reported specific patterns in the perception of affordances of the setters. Specifically, Ramos et al. (2017b) observed that even though elite female setters presented high instability (variation) in the perception of affordances, excellent distribution conditions led to an increased number of attacks in zone 3 (presenting faster attack times), suggesting that this tactical behavior would increase the opportunity to score in the game. We believe that our results differ from these because of the faster games played by males compared to females (Costa et al., 2012), and because the attack at the center of the court reduces the number of blockers faced by the attacker in women's volleyball (Afonso et al., 2010). The study by Rocha et al. (2020) also analyzed high-level women's volleyball and found that the setters' distribution location differed according to the distance between the setter and the central striker, the central blocker, and the blocker from position 4. These authors concluded that the perception of affordances for the setter's action was based on the availability of the central attacker and the configuration of the positioning of the blockers, reinforcing that in the female game, playing in the center of the court (zone 3) is beneficial to obtain a tactical advantage. The study by Rocha et al. (2021) analyzed high-level male volleyball and indicated that the setters' perception of affordances showed specific distribution patterns according to the distance between the setter and the attacker in position 4, the attacker in position 6, and the blocker in position 4. These results suggests that the setters' perception of affordances was related to the disposition of these attackers, which can hinder the opponent's defensive system. Moreover, the location of the blocker in position 4 was also decisive, since it may indicate whether this player will help the central blocker or not in the composition of the block. We consider that the differences between the results from the aforementioned studies and our results are justified by the number of setters analyzed in each study. Therefore, it is not possible to identify how much each one of their behaviors fluctuated within the distribution system.

The ecological dynamics logic suggests that skillful behavior (in our study determined by the high level of performance of the teams and athletes) arises from solutions adaptable towards intended performance, according to the possibilities of action (Woods et al., 2020a). At the methodological level, the measures and research variables must intent to capture the complex athlete-environment system. This environment can be expressed by eco-physical variables of performance behaviors, since these allow a direct assessment of the athlete in the performance environment. That is, they allow the analysis of the interaction between the structure of the athlete's action and a given performance environment (Araújo et al., 2020). Thus, the variability of functional movement is crucial to performance in complex systems, such as the ones high performance athletes experience. The variability allowed athletes to solve problems that emerges in the game in different ways, using diverse behaviors (Woods et al., 2020a).

The ecological dynamics framework also suggests that the behavior can be understood based not only in the characteristics of the athlete, but also considering its interaction with the characteristics of the competitive environment (Araújo et al., 2019). Thus, the possibilities for action depend on the dynamics existing between the athletes' continuous interactions with the respective environment (i.e., individual behaviors adjusting synergistically with teammates and according to the opponents' actions), allowing the analysis of sports performance to occur beyond performance ratifications (Araújo and Davids, 2016).

Considering the interacting essence of our analysis, our findings suggest that the high variability of the setters is based on their adaptations to the situational demands, according to the possibilities of action and in the expectation of generating instability in the opponent's defensive system, a fact that would provide tactical advantage in the offensive game. This notion is supported by the similar distances found between the setter and the central attacker and between the setter and the central blocker, indicating that the blocker avoided anticipating the setter's actions, choosing to react to the setter's action instead. In addition, it is very likely that both teams analyzed each other throughout the competitions (i.e., analysis of games played against other opponents). As a result, it is expected that coaches tried to diversify the pre-established distribution patterns, in an attempt to surprise the opponent's defensive system and to difficult its structuration. These aspects may explain the lack of distribution patterns in setters under excellent setting situations in our study.

Conclusions

To summarize, when considering the performance of three high-level setters in World Championship final matches, we observed that perception of affordances caused uncertainties in the opponent's defensive system which prevented anticipatory behaviors from the opposing central blocker due to the high variability observed. No significant differences were demonstrated between the distances concerning setting zones, the outcome of the sets, and scoring blocks throughout sets. The distance between the setter and the central attacker and between the setter and the central blocker does not indicate a distribution pattern for the high-performance setters analyzed, thus confirming our hypothesis that setters would present high variability in the perception of affordances through playing environment constraints. As practical implications, coaches should emphasize practice settings the emphasize players' interaction, so that setters' perceptions of affordances on distribution patterns are developed with greater variability, considering the ecological dynamic approach. Nonetheless, further research on the perception of affordances process in sport is warranted. The analysis of game situations without optimal setting conditions, the adoption of different echo-physical variables, and the investigation of entire competitions to verify whether such variables differ in teams with different performance levels are some of the topics that may contribute to the understanding of the perception of affordances process under the framework of the ecological dynamics.

Acknowledgments: We thank the staff of the Sada Cruzeiro volleyball team for providing the recorded images of the matches that allowed carrying out this research. In addition, the authors thank Erica Pratt of the VIBES Editorial Group SportsEdTV Foundation for reviewing and commenting on this manuscript.

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

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

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