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The Attack in Volleyball from the Perspective of Social Network Analysis: Refining Match Analysis through Interconnectivity and Composite of Variables

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Abstract

This study aimed to develop an instrument for analysing the attack in high-level volleyball considering the refined variables adjacent to the attack action, the interconnection between direct and indirect actions, the impact of the previous action, and the formation of composite variables. The game complexes were approached as interacting subsystems. The primary goal was to understand the influence of game actions adjacent to the attack. Three matches of a National Women's 1st Division 2018/2019 (nine sets, 415 plays) were analysed, considering all game complexes (except attack coverage due to reduced occurrence). An Eigenvector Centrality network with 420 nodes and 7367 edges was created. The networks showed that ideal setting conditions, and strong attacks by the outside and opposite hitters without having received a perfect ball, were central in side-out. In transition, we highlight ideal setting conditions, preferences of the outside hitter, quick attacks in Z4, and high balls in Z2. This study is distinct because it considers different aspects related to the systemic review of the game by using composite variables and the actions prior to the attack. Of these results, we highlight that players attacked with slower tempos for the double action of receive-attack, and these were either preferably directed to the parallel or explored the block. Moreover, for the double defence-attack actions, attackers sought the soft spike in Z2, Z4, and Z8; and when two consecutive individual errors occurred, the players did not err but instead continued to attack to force the opponent's error.

Keywords: *performance analysis, game analysis, social network analysis, eigenvector centrality, attack, volleyball*

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Introduction

The study and development of team sports can be conceptualized at three levels with performance analysis as an umbrella concept, match analysis as a sub-genre within performance, and Social Network Analysis as a specific tool for conducting match analysis. Performance analysis refers to the interpretation of different performance indicators for the optimization of the training process and matches (Hughes, 2004). One of

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its primary objectives is to provide feedback to athletes and coaches to support decision making (Hodges & Franks, 2008). Match analysis, the process of recording individual game actions within a play context (Hughes & Franks, 2008), is one possible application of performance analysis. Match analysis has contributed positively to volleyball research on the influence of reception quality, attack tempo and block type on attack efficacy (Costa, Afonso, Barbosa, Coutinho, & Mesquita, 2014); on the performance links between game actions and the final ranking in the league (Conejero, Claver, González-Silva, Fernández-Echeverría, & Moreno, 2017); and on the creation of references to understand team performance in certain game actions by means of a longitudinal study (Drikos & Tsoukos, 2018).

Social Network Analysis has established itself as a powerful tool for match analysis, particularly when focusing on behaviour and the relationships between the players involved in the network (captured by nodes and connected by edges; Borgatti, 2005; Wäsche, Dickson, Woll, & Brandes, 2017). Studies have mostly focused on match analysis with the nodes centred on the players (Ribeiro, Silva, Duarte, Davids, & Garganta, 2017). Thus far, the most common measure has been degree centrality (e.g., Gama et al., 2014; McLean, Salmon, Gorman, Stevens, & Solomon, 2018), which calculates the number of direct connections between nodes (Borgatti, 2005). However, recent research in volleyball (Laporta, Afonso, and Mesquita, 2018a; 2018b; Laporta, Afonso, Valongo, and Mesquita, 2019) has applied Eigenvector Centrality, which considers the value of a node as the weighted sum of both direct and indirect connections (Bonacich, 2007). Moreover, such studies have begun to consider game actions, and not only players, as nodes (e.g., Hurst et al., 2016; Laporta et al., 2019).

These studies made significant contributions to the literature, but most had limitations concerning the way in which attack actions were analysed. These limitations included a limited consideration of game actions without the ball, using tools with relatively limited levels of efficacy and, most notably, the analysis of each action without considering the outcome of previous attack actions. We aim to overcome these limitations to give a greater systematic overview of the game. Moreover, we also aim to address the limitation of conducting match analysis via interconnectivity and compositive variables. For match analysis to be representative of the game, interactions between current and previous actions, and the effects of prior efficacy on current efficacy, should be considered.

In sum, the overarching goal of the current study was to develop a more comprehensive analysis of volleyball game actions. We aimed to meet this goal by testing a more refined instrument for analysing attack actions. This instrument considers the interconnection between direct and indirect actions, the influence of the previous action, and the formation of composite variables. Thus, because it was designed to consider the dynamics and complexity of the game, we anticipated this instrument would represent a fundamental tool aligned with the potential of Social Network Analysis.

Methods

Sample

We analysed three matches, corresponding to nine sets and 415 plays, from a National Women's 1st Division (2018/2019). All complexes were analysed. More specifically, we analysed the node corresponding to the attack action and its relations with other nodes (other game actions).

Variables

The variables were classified as either simple or composite (see Table 1). Volleyball is structured in seven interdependent game complexes with distinct game flow characteristics (Loureiro et al., 2017; Hurst et al., 2016): complex 0 (K0) or serve, Complex I (KI) or side-out, Complex II (KII) or side-out transition, Complex III (KIII) or transition, Complex IV (KIV) or attack coverage, Complex V (KV) or freeball, and Complex VI (KVI) or downball. We chose not to analyse KIV because of its low occurrence, with only 3.89% of ball possession in men and 4.1% in women (Laporta, 2014).

The simple variables analysed were server starting position (Data Volley, 2018; Fernández-Echeverría et al., 2017), type of serve (Afonso, Esteves, Araújo, Thomas, & Mesquita, 2012), serve relationship with the positioning of the screening, serve efficacy, first contact zone, type of reception contact, the function of the player who received or attacked (outside hitter (OH), libero (LB), middle-blocker (MB), opposite (OPP), setter (ST)) (adapted from Afonso et al., 2012), ideal vs non-ideal setting conditions (Hurst et al., 2016; Laporta et al., 2018b), availability of the middle-blocker (adapted from Afonso, Mesquita, Marcelino, & Silva, 2010), and the combination of attack with tempo (adapted from Afonso et al., 2010; Data Volley, 2018).

We also studied where the attacker establishes contact with the ball (the need to clarify the various attack tempos across the nine zones resulted in 20 combinations), attack trajectories (Data Volley, 2018), type of attack (based on the position of the attacker and attack efficacy; Data Volley, 2018), the behaviour of the block (e.g., its starting points; adapted from Afonso, Laporta, and Mesquita, 2017), behaviour prior to the setter (adapted from Afonso & Mesquita, 2011), block opposition being without blocks, and efficacy of the block (Data Volley, 2018). Composite variables were also coded: attack without/after receiving, attack after two consecutive errors, and attack after defence/undefended attack.

Data collection, procedures and reliability

First, a spreadsheet was built in Microsoft Excel 2017 with macro buttons to catalogue the necessary codes into the appropriate cells. The data collection procedures were then conducted, and intra-observer reliability evaluated using 10% of the total sample (cf. Fleiss, Levin, & Paik, 2013). For intra-observation reliability, Cohen's Kappa values ranged from .959 to .999. For inter-observation reliability, these values ranged from .774 to .997. Thus, all variables were greater than the threshold of 0.75 proposed by Tabachnick and Fidell (2007).

Next, data were analysed using SPSS for Windows (version 25, IBM®, USA), which included a verification of data quality followed by descriptive analysis and the production of cross tables. The software Gephi© was used to calculate the connections and their weights using Eigenvector Centrality. Node sizes were manipulated using the intrinsic units given by the software, set to vary between 300 and 1500 to ensure proper visual contrast.

Results

A global network of intra- and inter-complex interactions was established using Eigenvector Centrality to provide a map of interactions (Figure 1). To create an interactive network, the complexes were separated by colour: K0 (yellow), KI (red), KII (grey), KIII (green), KV (purple) and KVI (pink).

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Table 1. Study Variables

Variables	Category/Description	Complex	Simple/ Composite	New
Server starting position (SSP)	5 | 7 | 6 | 9 | 1 Zone1 (from the right sideline to 1.8m inside). Zone 9 (from the 1.8m on the right side to the centreline on the left). Zone 6 (most central parcel - from 3.6m to 5.4m). Zone 7 (from the 1.8m on the left side to the centreline on the right). Zone 5 (from the left sideline to 1.8m inside). Note, it is considered a fault if the player steps into the final line.	K0	Simple	
Type of serve (S)	Overhand serve (with displacement and explosive jump and with rotation of the ball) (OVHS). Float (no jump - serve in support) (FLT). Jump-float (no ball rotation and uniform trajectory) (JFLT).	K0	Simple	
Block screening (BC)	Sectorized in Z4 (CBZ4): from the left side line (near the net) to 3 metres indoor. Centralized in Z3 (CBZ3): from 3 to 6 metres (near the net). Sectorized in Z2 (CBZ2): from the right side line (near the net) to 3 metres indoor. BCZ4 | BCZ3 | BCZ2	K0	Simple	
Serve efficacy (SE)	# Ace (direct point). + Positive (it generates a perfect pass that allows the opponents' setter to set all combinations). ! Exclamatory (serve bulk but recovered). - Negative (the opponent receives the ball # and can attack in any way). / Poor (the reception of the opponent is poor. The ball is sent directly in the other court or cannot be attacked). = Error (point to opposition - net ball, out, foot foul).	K0	Simple	
Block starting points (BSP)	Open (BSPO) (3 network players are close to each other [1 metre], in the centre of the network). Closed (BSPC) (3 players on the block, are far away in the net, i.e., one in the centre of the network and the other two separated about 2m). Mixed to the right (BSPMR) (two of the players – middle-blocker and opposite – are close with about 1m – in Z2 and another (outside hitter) away from these, about 2 to 3m - in Z4 – i.e., to block the fast set of the middle-blocker). Mixed to the left (BSPML) (two of the players – central and outside hitter – are close to each other in 1m – in Z4 and another (opposite) away from these, about 2 to 3m - in Z2). No exist block starting points (NO).	K0	Simple	✓
Reception line (RL)	RL 3: 3 receivers. RL 2+1: 2 priority receivers (4.5 metres each) and 1 receiver with less reception space (only 1 metre). RL 4: 4 receivers.	KI	Simple	
1st contact zone (FCZ)	Zone 1 to 9.	KI to KVI	Simple	
Type of 1st contact (TFC)	R # (ball in hand for perfect setting, all combinations can be made – 4/5 valid options). R+ (reception within 3 metres with at least 3 attack points without all combinations). R+KM (Sectorized reception for Z2). R+KP (Sectored reception for Z4). R+K0 (Sectorized reception for Z8). R! (when reception is neither negative nor positive, usually when you can force the use of the middle-blocker). R- (reception outside 3 metres, with 3 valid options). R/ (direct reception to the opposition court). R= (error - direct point for the opposition).	KI	Simple	✓
Reception player function (RPJ)	Right side hitter (RH). Outside hitter (OH). Libero (Lb). Middle-blocker (MB). Opposite (OPP). Setter (ST).	KI	Simple	
Setting conditions (SC)	A (all attack options available). B (fast game, but no combined moves available). C (only available attackers from the ends or background court). NO (no exist).	KI to KVI	Simple	

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Variables	Category/Description		Complex	Simple/ Composite	New
Availability of the middle-blocker (AMB)	Quick attack on the front (in front of and near the setter) (QAF). Attack away at the front (in front and away from the setter) (AAF).	Quick attack on the back (on the back and close to the setter) (QAB). Attack away on the back (on the back and away from the setter) (AAB). NO (no exist).	KI	Simple	✓
Function of the attack player (ATAC)	Outside hitter (ATACOH). Middle-blocker (ATACMB). Opposite (ATACOP).	Setter (ATACST). NO (no exist).	KI to KVI	Simple	
Attack Zone/ Combination (AZ/Comb)	V4 X4 | X7 X9 | CE XT | CF X3 PR | CC C1 PP | CH X2 V2 — | XR | XP (spanning CE–CF) | XB | X1 V1		KI to KVI		✓
	V4 – high tempo in Z4 – (from 1.5m from the left line). X4 – fast tempo in Z4 – (from 1.5m from the left line). X9 – inside attack in Z4 – (1.5m inside, from V4). X7 – tempo away at the front, of the middle-blocker – (1.5m inside, from V4). XR – pipe in Z8/Z5 – (1.8m inside, from XP). CE – quick attack, slightly, near the setter, the middle-blocker – (1.5m inside, from X7). XT – combined play between middle-blocker and right side hitter – (1m inside, from X7). XP – centrality pipe attack on Z8 – (1.8m inside, from V1). CF – quick attack at the front and next to the setter, of the middle-blocker – (1.5m inside, from CE). X3 – combined move between middle-blocker and opposite – (1m inside, from CE). PR – penalty.	CC – quick attack on the back and next to the setter – (1.5m outside, from CF). C1 - inside attack in Z2 – (1.5m outside, from CF). PP – 2nd touch. XB – pipe in Z8/ Z1 – (1.8m inside, from XR). CH – quick and tense attack of the middle-blocker, away from the setter – (1.5m abroad, from CC). X2 – fast tempo in Z2 – (1.5m abroad, from CC). V2 – high tempo in Z2 – (1.5m abroad, from CC). X1 – fast tempo in Z1 – (from the right line to 1.8m inside). V1 – high tempo in Z1 - (from the right line to 1.8m inside). NO (no exist combination).		Simple	
Attack trajectories zones (ATZ)	Zone 1 to 9. NO (no exist).		KI to KVI	Simple	
Type of attack, based on the attacker's position (TpA)	**Strong attack:** Parallel (Z9/ Z1) – SAL. Paragonal/between blockers (Z6/Z8) – SAP. Small crosscourt (SASD).	Intermediate crosscourt (SAID). Great crosscourt (SAGD).	KI to KVI	Simple	✓
	Directed attack (Tip): Line (Z9/ Z1) – DAL. Paragonal/between blockers (Z6/Z8) – DAP. Small crosscourt (DASD).	Intermediate crosscourt (DAID). Great crosscourt (DAGD).		Simple	✓
	Combined: Scissors (Z4/Z2) – ACSc. Up-and-down (Z4/Z2) – ACUaD.	Inside (Z4/Z2) – ACIn.		Simple	✓
	Soft spike: Z1 – AmoZ1.; Z2 – AmoZ2.; Z3 – AmoZ3. Z4 – AmoZ4.; Z5 – AmoZ5.; Z6 – AmoZ6.	Z7 – AmoZ7.; Z8 – AmoZ8.; Z9 – AmoZ9.		Simple	✓
	Exploration of the block: Block-ou side (BOS) – ball is reflected in the block to the sideline. Block-out Long (BOL) – ball is reflected to the back line. Block-out In (BOI) – do not confront the block: attack against it, to regain the ball again.			Simple	✓
	No exist type of attack (NO).			Simple	

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Attack efficacy (AE)	#	Perfect (point).			KI to KVI	Simple	
	+	Positive (attack that causes difficulty to opposing defence).					
	!	Exclamatory (attack bulk but recovered).					
	-	Negative (attack defended with ease).					
	/	Poor (attack blocked with kill and error).					
	=	Error (point to opposition).					
	NO	No exist efficacy.					
Results of previous actions (RPA)	Attack after receiving (AaR)		R# R+	R- R!	KI	Composite	✓
	Attack without receiving (AwR)		R# R+	R- R!	KI	Composite	✓
	Attack after 2 consecutive errors (Aa2Ce)		Individual (Ind) Collective (Cole)	No exist (AaENO)	KI to KVI	Composite	✓
	Attack after defending (AaD)		D # D +	D -	KI to KVI	Composite	✓
	Attack without defending (AwD)		D # D +	KI to KVI	KII, KIII, KV and KVI	Composite	✓
	AaesDNO		No attack occurred after reception/defence		KI to KVI	Composite	✓
Behaviour prior to the setting action (BPS)	This behaviour is intended for the middle-blocker player: Wait (BPSW): read and react strategy. Commit (BPSC) (strategy to anticipate the setter action):	BPSCFA – commit with faster attack closer. BPSJS – jump to the 2st touch or attack of the setter. Follow (BPSF) (strategy of following the opposing setter or the receipt or specific player):	BPSDZ4 – displacement from middle-blocker to Z4. BPSDZ2 – displacement from middle-blocker to Z2. BPSNO – no exist.		KII and KIII	Simple	✓
Block opposition (BOp)	Cohesive block: there is no space between blockers – the attacker cannot exploit their failures Open block: there's space between blockers. Broken block: the one in which the blocker arrives late, compensating with her arms diagonally.	No block; backs down to defend (B0BD). No block with merit of the opposition (B0WMO). Simple block, by choice (B1CH). Late simple block (B1L). Simple block with opposition merit (B1WMO).	Cohesive double block (B2C). Open double block (B2O). Double block broken without reaction to retreat and defend (B2WRRD). Cohesive triple block (B3C). Open/broken triple block (B3O). Impossible to analyse the block, i.e.: setter error (IAB). No block (BNO).		KII and KIII	Simple	✓
Block efficacy (BE)	#	Winning (direct point).			KII and KIII	Simple	
	+	Positive (the ball is touched and can be played again by the home team or point goes to the other team).					
	-	Poor (the opponent can play the ball again).					
	=	Error (hands out, net ball, ball in own side or opposite side).					
	NO	No block efficacy.					

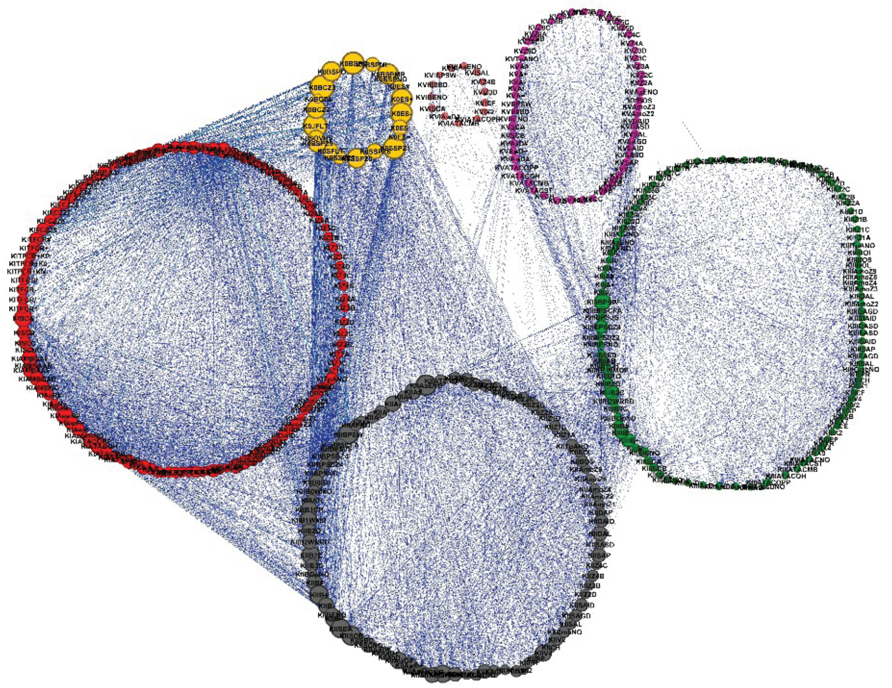

FIGURE 1. Network of the six complexes, with Eigenvector Centrality. Terminology: On each node, the codes are represented by the name of the complex, followed by the variable and its category. For example, KIIATACOH indicates that the action occurred in complex II, the variable in question was the function of the attacker, in this case, the outside hitter. The codes for the different variables: SSP – server starting position; S – type of serve; BC – screening block; BSP – block starting point; SE – serve efficacy; RL – reception line; RJP – player's reception function; FCZ – first contact zone; TFC – type of first contact; SC – setting conditions; AMB – availability of the middle-blocker; AAEWEX – attack after or without receive/defend; ATAC – attacker function; CMB – combination of attack; ATZ – attack trajectory zone; TpA – type of attack; AAE – attack after error; AE – attack efficacy; BPS – behaviour prior to the setting action; BOp – block opposition; BE – block efficacy. The EC values corresponding to each of the variables per complex are expressed in Table 2. In the K0, we highlight the values of; the jump-float serve, of serving from Z1, of the block screening in Z3, and serve efficacy being negative or positive. In KI, the most used was ideal setting conditions compared to the non-ideal. The most requested player in side-out was the OH, followed by OPP and MB. Concerning the attack, mostly it was without receiving but with the perfect ball followed by without receiving but with the positive ball. In situations in which the attacker received a perfect or positive ball and then attacked, the attackers sought to attack directed to the parallel, soft spike in Z9, or explored the block. Conversely, the attack tempo was fast on the Z4, slow on Z2 and the MB to attack CF and CH. In turn, the type of attack was either a strong attack on the parallel, a paragonal-directed attack, a great crosscourt or a crosscourt intermediate attack with a great efficacy of attack. As for the attack after two collective errors, the players sought the most controlled attack on the small crosscourt and the soft spike (Z3 and Z2).

The EC values for each of the variables per complex are presented in Table 2. In K0, we highlight the values for several variables: the jump-float serve, serving from Z1, the block screening in Z3, and serve efficacy being negative or positive. In KI, ideal setting conditions were more often used than non-ideal setting conditions. The most requested player in side-out was the OH, followed by OPP and MB. Most attacks happened without receiving and with a perfect ball. The second most common type of attacks happened without receiving and with a positive ball. In situations in which the attacker received a perfect or positive ball and then attacked, the attack was directed to the parallel, there was a soft spike in Z9, or the block was explored. The attack tempo was fast on the Z4, slow on Z2, and the MB tended to attack CF and CH. In turn, the type of attack was either a strong attack on the parallel, a paragon-directed attack, a great crosscourt, or a crosscourt intermediate attack with a high attack efficiency. In the case of the attack after two collective errors, the players sought the most controlled attack on the small crosscourt and the soft spike (Z3 and Z2).

In KII, the block was characterized by a wait, due to the conditions of the setter (mostly ideal), and the block opposition was double cohesive or individual. The most requested player was the OH. The most used attack tempos were the quick ball (in Z4), the high ball (in Z2), and CF from MB. As for the type of attack, it was used in the directed attack in line, as well as the strong attack in paragonal/between blockers and the strong attack in intermediate crosscourt. When players attacked after a positive defence, they looked for the soft spike in zones 2, 8, and 4. In KIII, the behaviour prior to the setting action was often waiting or to accompany to Z4, due to the higher occurrence of SCB followed by SCA and SCC, with block opposition being, mostly, double cohesive. The most requested attackers were the extremities (OH and OPP). The trajectories most performed by these attackers were the strong attack on the parallel, on the great crosscourt, and an attack tempo with the high ball. In KV, the ideal setting conditions predominated, followed by many attacks not preceded by perfect defences, and the most requested player was OH (who always had quick balls and sought to attack the parallel). The behaviour of the opposition block was always to wait. Finally, in KVI, due to its low occurrence (only twice), the ideal setting conditions and the attack of the MB were highlighted.

Discussion

In Social Network Analysis, interaction networks analyse the degree of connection and specificity in the different phases of a game, thus helping to identify the most influential critical

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actions in the flow of the game (Wäsche et al., 2017). Eigenvector Centrality weight both direct and indirect connections between nodes (Laporta et al., 2018a; 2018b). The current study aimed to create a more refined instrument for studying the attack in volleyball. This instrument considers the interconnection between direct and indirect action, the impact of the previous action, the use of composite variables, and adding a finer-graining filter to the analysis (i.e., by using specific variables surrounding the attack). Our data illustrate the complex dynamics of the game actions within each phase of the game and highlight the decisive role of each node, which aids in providing a more detailed perspective of the phenomena that occur within the interactive network.

Our results regarding specific variables are consistent with the literature (Costa et al., 2014; Laporta et al., 2018b) in that they show the most requested player in the attack was the outside hitter (followed by the opposite) and that the tempo of the attack included quick ball attacks at Z4 and high ball at Z2

Table 2. Eigenvector Centrality values for Complex

Complex	Variable	Eigenvector Centrality values
K0	Server starting position (SSP)	Z1 (0.83); Z5 (0.69); Z6 (0.60); Z7 (0.49); Z9 (0.60)
	Type of serve (S)	OVHS (0.44); FLT (0.58); JFLT (0.85)
	Block screening (BC)	Z2 (0.62); Z3 (0.87); Z4 (0.18)
	Block starting points (BSP)	BSPO (0.67); BSPC (0.78); BPSMR (0.72); BSPML (0.46); BSPNO (0.21)
	Serve efficacy (SE)	S# (0.20); S+ (0.73); S! (0.53); S- (0.77); S= (0.13)
KI	Reception line (RL)	3 (0.29); 2+1 (0.14); 4 (0.11)
	1st contact zone (FCZ)	Z1 (0.20); Z2 (0.15); Z3 (0.08); Z4 (0.10); Z5 (0.21); Z6 (0.25); Z7 (0.25); Z8 (0.25); Z9 (0.25)
	Type of 1st contact (TFC)	R# (0.32); R+ (0.27); R+KM (0.20); R+KP (0.20); R+K0 (0.19); R! (0.26); R- (0.24); R/ (0.20); R= (0.19)
	Reception player function (RPJ)	OH (0.25); RH (0.26); Lb (0.29); MB (0.14); OPP (0.09)
	Setting conditions (SC)	A (0.77); B (0.55); C (0.47); NO (0.07)
	Availability of the middle-blocker (AMB)	QAF (0.70); AAF (0.69); QAB (0.61); AAB (0.46); NO (0.54)
	Function of the attack player (ATAC)	OH (0.68); MB (0.57); OPP (0.64); ST (0.33); NO (0.13)
	Attack without receiving (AwR)	R# (0.71); R+ (0.60); R- (0.53)
	Attack after receiving (AaR)	R# (0.34); R+ (0.34); R- (0.30)
	Attack after 2 consecutive errors (Aa2E)	Colec (0.35); NO (0.80)
	Attack Zone/Combination (Cmb)	XP (0.34); V2 (0.49); X2 (0.34); PP (0.29); CF (0.37); CE (0.25); X9 (0.29); X7 (0.30); V4 (0.62); X4 (0.53); X1 (0.13); CC (0.22); XR (0.31); CH (0.39); V1 (0.30); N0 (0.12)
	Attack trajectories zones (ATZ)	Z1B (0.23); Z1C (0.24); Z2A (0.28); Z2B (0.41); Z2C (0.42); Z2D (0.31); Z3B (0.34); Z3C (0.25); Z3D (0.37); Z4A (0.33); Z4B (0.34); Z4C (0.36); Z4D (0.33); Z5B (0.37); Z5C (0.15); Z6A (0.17); Z6B (0.26); Z6C (0.34); Z6D (0.27); Z7A (0.26); Z7B (0.31); Z8A (0.24); Z8B (0.37); Z8C (0.34); Z8D (0.26); Z9A (0.26); Z9B (0.24); Z9C (0.45); Z9D (0.41)
	Type of attack (TpA)	SAL (0.52); SAP (0.57); SASD (0.30); SAID (0.48); SAGD (0.49); DAL (0.33); DAP (0.49); DASD (0.36); DAID (0.46); AmoZ2 (0.33); AmoZ3 (0.36); AmoZ4 (0.35); AmoZ8 (0.26); AmoZ9 (0.22); BOS (0.34); BOI (0.30); BOL (0.30); NO (0.32)
	Attack efficacy (AE)	A# (0.66); A+ (0.52); A/ (0.6447 A- (0.64); A! (0.29); A= (0.51); NO (0.18)
KII	Behaviour prior to the setting action (BPS)	BPSW (1); BPSCFA (0.48); BPSJS (0.28); BPSDZ4 (0.76); BPSDZ2 (0.57); BPSNO (0.13)
	Block opposition (B)	B0BD (0.69); B0WMO (0.30); B1CH (0.78); B1WMO (0.76); B2C (0.89); B2O (0.70); B2WRRD (0.53); B3C (0.61); IAB (0.24); OpBNO (0.13)
	Block efficacy (BE)	B# (0.64); B+ (0.95); B- (0.89); B= (0.86); EBNO (0.46)
	Setting conditions (SC)	A (0.75); B (0.75); C (0.35); NO (0.43)
	Function of the attack player (ATAC)	OH (0.58); MB (0.47); OPP (0.49); ST (0.25); NO (0.24)
	Attack without defending (AwD)	D# (0.59); D+ (0.54); D- (0.24)
	Attack after defending (AaD)	D# (0.21); D+ (0.31); D- (0.14)
	Attack after 2 consecutive errors (Aa2E)	NO (0.69)
	Attack Zone/Combination (Cmb)	XP (0.27); V2 (0.40); X2 (0.15); PP (0.25); CF (0.33); X7 (0.26); V4 (0.50); X4 (0.46); PR (0.19); CH (0.22); NO (0.23)
	Attack trajectories zones (ATZ)	Z1A (0.20); Z1C (0.28); Z1D (0.11); Z2A (0.15); Z2B (0.34); Z2C (0.32); Z2D (0.23); Z3B (0.20); Z4B (0.29); Z4C (0.25); Z6B (0.18); Z6C (0.24); Z7B (0.29); Z7C (0.31); Z8D (0.34); Z9C(0.35); Z9D (0.26); NO (0.23)
	Type of attack (TpA)	SAL (0.34); SALP (0.39); SASD (0.24); SAID (0.33); SAGD (0.32); DAL (0.40); DAP (0.27); DAID (0.33); AmoZ1 (0.15); AmoZ2 (0.28); AmoZ4 (0.20); AmoZ8 (0.22); AmoZ9 (0.19); BOS (0.29); BOI (0.24); NO (0.30)
	Attack efficacy (AE)	A# (0.52); A+ (0.38); A/ (0.29); A- (0.45); A! (0.28); A= (0.33); NO (0.21)

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Complex	Variable	Eigenvector Centrality values
KIII	Behaviour prior to the setting action (BPS)	BPSW (0.57); BPSCFA (0.13); BPSDZ4 (0.14); BPSDZ2 (0.33); BPSNO (0.15);
	Block opposition (B)	B0BD (0.29); B1CH (0.27); B1O (0.11); B1WMO (0.32); B2C (0.50); B2O (0.30); B2WRRD (0.21); B3C (0.20); IAB (0.01); OpBNO (0.05)
	Block efficacy (BE)	B# (0.24); B+ (0.41); B- (0.37); B= (0.44); EBNO (0.21)
	Setting conditions (SC)	A (0.13); B (0.13); C (0.08); NO (0.06)
	Function of the attack player (ATAC)	OH (0.07); MB (0.03); OPP (0.06); ST (0.01); NO (0.006)
	Attack without defending (AwD)	D# (0.06); D+ (0.05); D- (0.03)
	Attack after defending (AaD)	D# (0.02); D+ (0.009); D- (0.01)
	Attack after 2 consecutive errors (Aa2E)	NO (0.09)
	Attack Zone/Combination (Cmb)	XP (0.03); V2 (0.05); X2 (0.02); PP (0.02); CF (0.01); CE (0.01); X9 (0.02); X7 (0.02); V4 (0.05); X4 (0.03); PR (0.01); X1 (0.01); XB (0.01); XR (0.01); CH (0.01); NO (0.007)
	Attack trajectories zones (ATZ)	Z1A (0.01); Z1B (0.03); Z1C (0.03); Z1D (0.01); Z2A (0.02); Z2B (0.02); Z2C 0.02); Z2D (0.03); Z3A (0.03); Z3B (0.02); Z3C (0.01); Z3D (0.02); Z4A (0.01); Z4B (0.01); Z4C (0.02); Z4D (0.01); Z5B (0.02); Z5C (0.01); Z5D (0.01); Z6B (0.01); Z6C (0.02); Z6D (0.01); Z7A (0.02); Z7B (0.02); Z7C (0.01); Z7D (0.01); Z8A (0.03); Z8B (0.01); Z8C (0.02); Z8D (0.02); Z9A (0.03); Z9B (0.03); Z9C (0.03); Z9D (0.01); NO (0.001);
	Type of attack (TpA)	SAL (0.04); SAP (0.03); SASD (0.01); SAID (0.03); SAGD (0.04); DAL (0.03); DASD (0.03); DAID (0.02); DAGD (0.01); AmoZ2 (0.03); AmoZ3 (0.03); AmoZ4 (0.01); AmoZ8 (0.01); AmoZ9 (0.02); BOS (0.02); BOI (0.01); BOL (0.01); NO (0.02)
	Attack efficacy (AE)	A# (0.07); A+ (0.05); A/ (0.02); A- (0.04); A= (0.04); NO (0.007)
KV	Behaviour prior to the setting action (BPS)	BPSW (0.14)
	Block opposition (B)	B0BD (0.13)
	Block efficacy (BE)	NO (0.11)
	Setting conditions (SC)	A (0.19); B (0.07)
	Function of the attack player (ATAC)	OH (0.15); MB (0.11); OPP (0.10); ST (0.04)
	Attack without defending (AwD)	D# (0.18); D+ (0.06)
	Attack after defending (AaD)	D# (0.03)
	Attack after 2 consecutive errors (Aa2E)	NO (0.17)
	Attack Zone/Combination (Cmb)	CC (0.04); CF (0.08); PP (0.04); XB (0.04); X7 (0.04); X9 (0.03); X4 (0.11); V4 (0.09); V2 (0.05); X2 (0.12); CH (0.05)
	Attack trajectories zones (ATZ)	Z2A (0.03); Z2C (0.07); Z3A (0.07); Z3C (0.04); Z3D (0.04); Z4A (0.04); Z4C (0.08); Z5C (0.04); Z5D (0.04); Z6C (0.05); Z7A (0.08); Z7B (0.04); Z7D (0.06); Z8A (0.05); Z8B (0.05); Z8C (0.04); Z9A (0.05); Z9B (0.05); Z9C (0.05); Z9D (0.07)
	Type of attack (TpA)	SAL (0.13); DASD (0.04); BOS (0.04); SAGD (0.08); SAP (0.09); SASD (0.08); SAID (0.05); DAID (0.07); AmoZ2 (0.03); AmoZ3 (0.06); NO (0.04)
	Attack efficacy (AE)	A# (0.12); A+ (0.09); A/ (0.06); A- (0.07); A= (0.05)
KVI	Behaviour prior to the setting action (BPS)	BPSW (0.03)
	Block opposition (B)	B0BD (0.05)
	Block efficacy (BE)	NO (0.04)
	Setting conditions (SC)	A (0.04)
	Function of the attack player (ATAC)	MB (0.03); OPP (0.03)
	Attack without defending (AwD)	D# (0.03)
	Attack after 2 consecutive errors (Aa2E)	NO (0.03)
	Attack Zone/Combination (Cmb)	CF (0.03); X2 (0.03)
	Attack trajectories zones (ATZ)	Z3D (0.03); Z4D (0.03)
	Type of attack (TpA)	SAL (0.03)
	Attack efficacy (AE)	A- (0.03)

(perhaps due to the characteristics of the players; Marcelino, Afonso, Moraes, & Mesquita, 2014). Concerning the type of attack, it is worth noting the strong attack on the paragonal and parallel, the strong attack on the crosscourt (great and intermediate), the attack directed to the parallel and exploration of the block (side and long) because of the frequency of the block playing on wait and presenting between double and late cohesive or on setting merits. However, our results indicated that most of the game takes place between ideal setting conditions (i.e., A and B), which contradicts some previous research

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(Laporta et al., 2018b).

This study highlights the importance of conducting research using more refined variables (Laporta et al., 2019), with better definitions and categories; by using composite variables, thus considering interconnections between actions (direct and indirect) and the impact of the previous actions, it respects to a much greater extent the dynamic and complex systematic review of the game. The refinement of variables is fundamental to understanding the strength between nodes. In this study, the composite variables do not fragment the game and highlight the edges of the network (both in its direction and in its weight). Hence, it was demonstrated that coupled actions (e.g., receive-attack and defend-attack) statistically influence the setters' choices. Here, Eigenvector values reflected a centrality for the slowest attack tempos and trajectories attempting strong attacks in the parallel, soft spikes closer to the net, or exploration of the block (Afonso et al., 2012; Marcellin et al., 2014). It should be noted that seven new variables were created in this study.

The edges of our network clearly showed that when an attacker commits two consecutive attacking errors, they tried not to commit unforced errors in the third attempt, decreasing the assumed risk and allowing the continuity of the game. Moreover, our results revealed ideal setting conditions in KIII (SCB and SCA) as well as quick attack tempos. This finding directly contradicts Laporta et al. (2018b), who referred to non-ideal setting conditions (B and C) in KIII. Thus, our study adjusts to the idea of Marcelino et al. (2014) in which the strike depends on the interaction of several tactical-technical indicators that change the strategies of the teams, providing a systemic understanding of the game.

The large number of variables resulted in a very extensive instrument. Consequently, we will take the following steps for refinement. Firstly, we will aggregate the 36 subcategories for the attack trajectory zone (e.g., instead of Z9A-Z9D, assume solely as Z9) into nine variables. Second, the classification of the reception in KI will be reduced from nine categories to six. Third, when classifying the quality of the first touch, we found there was a direct relationship with the setting conditions (A, B or C), which in our view means it is possible to use only the classification of the setting conditions. Fourth, we will combine KVI with KV due to the rare occurrence of the first complex (twice). Finally, we will eliminate the availability variable of the MB in KI because it will have little influence on the attack.

This study has demonstrated that playing patterns are diverse and that play occurs in ideal setting conditions (B and A) in most complexes, which contradicts some of the results of Laporta et al. (2018b). Studies of this nature have practical implications for coaches, who should consider training in both ideal and non-ideal setting conditions and diversify attack patterns under various conditions. A substantial intra- and inter-complex relationship, which highlights the dynamics and complexity of the game actions, was also identified. Both KI and KII shared ideal setting conditions, outside hitter preference and parallel attack. For the KI-KII and KII-KIII interconnection, the behaviour of the block occurs most centrally on a waiting strategy and the attack tempo is quicker at one edge than at the other. This complex correlation is crucial for coaches to understand because it allows them to promote game scenarios based on previous actions or complexes (Paulo et al., 2018). This instrument has the potential to promote the use of Social Network Analysis in match analysis because it allows for a greater reading of the complexity and dynamics of the game (Passos et al., 2011; Ribeiro et al., 2017; Sasaki, Yamamoto, Miyao, Katsuta, & Kono, 2017), based on its systemic review. As for avenues to explore in future studies, Social Network Analysis and Eigenvector Centrality should be incorporated into research that addresses contextual variables (punctual difference, set/game moment and intra- and inter-set relationships).

In conclusion, the present study makes several significant contributions to volleyball research. It offers a more refined instrument than currently available in the literature, takes a more specific approach to attack variables, reinforces the importance of considering adjacent variables, and highlights the relevance of indirect connections. Hence, composite variables, interconnections between actions (direct and indirect), and the impact of the previous action are variables that consider the game flow and its interconnectivity. It is clear from the results that this instrument has the potential to advance both volleyball and the construction of instruments in other team sports. Finally, the study demonstrates that Social Network Analysis is a crucial tool for understanding the systemic and complex nature of the game.

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