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Original Article

There are differences between centrality levels of volleyball players in different competitive levels?

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Abstract:
The aim of this study was to analyse the variance of network centrality levels between different competitive levels and tactical positions during attacking moments. Twenty-four volleyball players (U12 – 12 players, 11.7 ± 0.4 years old, 1.9 ± 0.9 years of practice; Amateurs – 12 players, 24.9 ± 4.2 years old, 12.6 ± 2.8 years of practice) voluntarily participated in this study. The multivariate MANOVA revealed no statistical differences in the independent variable of competitive level ($\lambda = 0.001$; $F_{(3,22)} = 0.001$; p-value = 1.000; $\eta^2 = 0.001$; Very Small Effect Size). Statistical differences were found in the independent variables of tactical position ($\lambda = 1.015$; $F_{(15,72)} = 2.454$; p-value = 0.006; $\eta^2 = 0.338$; Moderate Effect Size). The post hoc values revealed that position 3 is the prominent player during attacking moments in both competitive levels and that position 5 reveals the smallest centrality levels in attack.
Key words: match analysis; volleyball; attack; network; metrics.

Introduction

The use of individual performance indicators in team sports have been used to improve the accuracy of sports training methodology (Hughes & Bartlett, 2002). One of the relevant performance components it is the match analysis that is carried-out in order to increaser the knowledge about the technical/tactical performance in competitive contexts (Carling, Reilly, & Williams, 2009). Such analysis allows to coaches and sport scientists identify some patterns of play and also to characterize the regular actions made by specific players (Franks & McGarry, 1996).

In the specific case of volleyball, the individual actions are too important to make decisions about how players should be organized by coach (Marelic, Resetar, & Jankovic, 2004). Relevant findings have been suggesting that the more important indicators that contributes for the success are the spike and the serve (R. Marcelino, Mesquita, & Afonso, 2008). Moreover, it is also found that in volleyball matches better attack occurs in the beginning of the set (first 15 rallies) (R. O. Marcelino, Sampaio, & Mesquita, 2012). Finally, in a generic summary the winning teams make fewer errors and are more effective and the losing teams make a superior number of continuity types of attacks (Monteiro, Mesquita, & Marcelino, 2009).

Nevertheless, one relevant and preliminary factor that has been fewer studied is the beginning of each attack and the attacking building. The initial step of attack may be influenced by opponent's serve or spike, the first contact in reception and the defence (Barzouka, Nikolaidou, Malousaris, & Bergeles, 2006). Following, the sequence of passes (pass and setting actions) between teammates it is a very important indicator to successfully conclude the attack (Afonso, Esteves, Araújo, Thomas, & Mesquita, 2012). This sequence of passes is constrained by the teammates' relationship. In the specific case of teammates interactions, a recent study suggested that serve-reception is one of the fundamental moments to determine the setting zone where libero's position assumes a prominent level. Middle-attackers exhibit a more effective serve and the extremes of the field (longitudinal and lateral axis) shows to be less effective in reception moment (Afonso et al., 2012). These findings assume relevant information to perform a new approach to the performance analysis in volleyball.

The way in which teammates cooperate to conclude the attack may be considered as a specific relationship. For that reason, the teammates' interactions with ball can be considered a network. The network point-a-view based on social network analysis it is a methodological approach that had a set of metrics that indicate general properties of the group, centrality levels of players and identify the patterns of interactions (Wasserman & Faust, 1994). The applications of network methodology in team sports it is relatively new (Duch, Waitzman, & Amaral, 2010; Grund, 2012). The majority of studies are carried-out in soccer (Clemente, Couceiro, Martins, & Mendes, 2015; Clemente, Martins, Kalamaras, Wong, & Mendes, 2015; Peña & Touchette, 2012) and in basketball (Bourbousson, Poizat, Saury, & Seve, 2010; Fewell, Armbruster, Ingraham, Petersen, & Waters, 2012). No study using social network analysis based o graph theory it was found for volleyball case.

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By the reason of small amount of published studies based on teammates' interactions in the attacking building of volleyball and the application of social network analysis in volleyball, the aim of this study was to identify the prominence level (measured by network centrality metrics) of each tactical position for the attack and to analyse the differences between such positions. Moreover, two competitive levels will be analysed in order to identify possible variances among ages.

Methods

Participants

Twenty-four volleyball players (U12 – 12 players, 11.7 ± 0.4 years old, 1.9 ± 0.9 years of practice; Amateurs – 12 players, 24.9 ± 4.2 years old, 12.6 ± 2.8 years of practice) from two teams of the Portuguese regional league voluntarily participated in this study. All parents (in the case of U12 players) and amateur players signed the Free and Clarified Consent Form according to the Declaration of Helsinki. All participants had been previously trained for a five-month period with three volleyball-specific training sessions per week, each lasting for 80 min to 100 min, and one weekly competition.

Sample

A total of 6 matches (3 matches per each competitive level) from the Portuguese regional League were analysed and codified. A total of 1,314 passes between teammates were recorded and processed (632 in the case of U12 and 682 in the case of Amateurs). In the case of U12 there were only three sets per match. In the case of Amateurs there were two sets of four and one set of three. From the analysis, there were generated six adjacency matrices that were then treated for social network analysis.

Data Collecting and Codification

The tactical lineup of the teams was used to codify the tactical position of each player and such classification can be following observed: 1) P1; 2) P2; 3) P3; 4) P4; 5) P5; and 6) P6. In order to clarify the line-up please considers the following Figure 1.

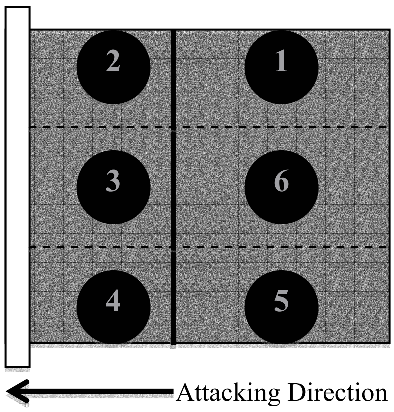

Fig. 1. Codification of tactical positions in volleyball.

To analyze the cooperation process during the attacking process it was considered as linkage indicator the pass between players. Per each unit of attack (sequence of passes between players from the ball receiving until the put the ball in the other field) it was generated an individual adjacency matrix. In the adjacency matrix (that contains the direction of passes between teammates) it was codified with 1 (one) the pass performed from player A to player B and with 0 (zero) when no pass it was performed between teammates. Moreover, in this specific study it was studied a digraph that means that direction it was considered, thus it is not the same a pass from player A to Player B and a pass from player B to player A.

The observation of passing sequence it was performed for the same researcher in order to avoid inter-observer errors. The reliability of data collection it was ensured by a test-retest for 10% of the full data. The test-retest it was made with a 20-day interval. The Cohen's Kappa test it was used and a value of 0.92 it was obtained, thus ensuring a recommended margin for this type of procedures (Robinson & O'Donoghue, 2007).

Network Metrics

For this study on volleyball players it were used three centrality metrics of network. All these metrics were executed using the Social Network Visualizer (version 1.5.) (Kalamaras, 2014). Following, each metric will be presented by using the brief algorithm.

Out-degree Centrality

The out-degree centrality (ODC) measure the level of each player passes the ball for the teammates. The general algorithm of ODC for the specific case of weighted digraphs is (Wasserman & Faust, 1994):

$$C_{D-out}^{w}(n_i) = k_i^{w^{out}} = \sum_{j=1}^{n} a_{ij} \quad (1)$$

This algorithm can be used as standard measure (%ODC):

$$C'^{w}_{(D-out)}(n_i) = \frac{k_i^{w^{out}}}{\sum_{i=1}^{n}\sum_{\substack{j=1\\ j\neq i}}^{n} a_{ij}}, \quad (2)$$

that measure the proportion of each node that are adjacent to n_i.

In-degree Centrality

The in-degree centrality (IDC) measures the level which each player receives the ball from the teammates. The general algorithm for weighted digraphs of IDC it can be represented as (Wasserman & Faust, 1994):

$$P_D^{w}(n_i) = k_i^{w^{in}} = \sum_{j=1}^{n} a_{ji} \quad (3)$$

Once again, this algorithm can be used as standard measure (%IDC):

$$P'^{w}_{D}(n_i) = \frac{k_i^{w^{in}}}{\sum_{i=1}^{n}\sum_{\substack{j=1\\ j\neq i}}^{n} a_{ij}}, \quad (4)$$

that measure the proportion of each node that are adjacent to n_i.

PageRank

PageRank (PR) measures the overall prestige and prominence of each player for the team's network. The original algorithm can be presented as (Ma, Guan, & Zhao, 2008):

$$PR = (1-d) + d \cdot \sum_i \frac{PR(T_i)}{C(T_i)} \quad (5)$$

The updating version can be presented as (Ma et al., 2008):

$$PR = \frac{(1-d)}{N} + d \cdot \sum_i \frac{PR(T_i)}{C(T_i)} \quad (6)$$

Statistical Procedures

The influences of competitive level and tactical position factors on the %IDC, %ODC and %PR were analyzed using two-way MANOVA after validating normality and homogeneity assumptions. When the MANOVA detected significant statistical differences between the two factors, we proceeded to the two-way ANOVA for each dependent variable, followed by Tukey's HSD post-hoc test (O'Donoghue, 2012). Based on the non-interaction between factors (competitive level*tactical position) it was carried-out the one-way ANOVA per each factor (Maroco, 2012). The effect size (*partial eta square*) it was executed and the following scale it was adopted (Lakens, 2013): small, 0.2-0.49; moderate, 0.50–0.79; large, 0.80–1. All statistical analyses were performed using IBM SPSS Statistics (version 22) at a significance level of $p<0.05$.

Results

The multivariate MANOVA revealed no statistical differences in the independent variable of competitive level ($\lambda = 0.001$; $F_{(3,22)} = 0.001$; *p-value* = 1.000; $\eta^2 = 0.001$; *Very Small Effect Size*). Statistical differences were found in the independent variables of tactical position ($\lambda = 1.015$; $F_{(15,72)} = 2.454$; *p-value* = 0.006; $\eta^2 = 0.338$; *Moderate Effect Size*). No statistical differences were found in the interactions of competitive level*tactical position ($\lambda = 0.291$; $F_{(15,72)} = 0.515$; *p-value* = 0.924; $\eta^2 = 0.097$; *Very Small Effect Size*).

Based on the no interaction detected between factors, the one-way ANOVA for the factor competitive level found no statistical differences in the dependent variables of %IDC ($F_{(1,34)} = 0.001$; *p-value* = 0.998; $\eta^2 = 0.001$; *Very Small Effect Size*), %ODC ($F_{(1,34)} = 0.001$; *p-value* = 0.996; $\eta^2 = 0.001$; *Very Small Effect Size*) and %PR ($F_{(1,34)} = 0.002$; *p-value* = 0.962; $\eta^2 = 0.001$; *Very Small Effect Size*). The descriptive statistics can be found in the following table 1.

Table 1. Descriptive statistics of the Competitive Level.

	U12	Amateurs
%IDC	16.67 (9.56)	16.67 (1.90)
%ODC	16.68 (8.10)	16.66 (10.32)
%PR	16.66 (0.66)	16.67 (0.71)

The one-way ANOVA for the factor competitive level found statistical differences in the dependent variables of %IDC ($F_{(5,30)}$ = 4.579; *p-value* = 0.003; η^2 = 0.433; *Small Effect Size*), %ODC ($F_{(5,30)}$ = 4.330; *p-value* = 0.004; η^2 = 0.419; *Small Effect Size*) and %PR ($F_{(5,30)}$ = 2.775; *p-value* = 0.036; η^2 = 0.316; *Small Effect Size*). The post hoc values can be found in the following table 2.

Table 2. Descriptive statistics and post-hoc results for the Tactical Position.

	P1	P2	P3	P4	P5	P6
%IDC	8.13 (7.77)[c]	21.62 (5.00)	26.78 (12.13)[a,e]	21.10 (9.07)	9.41 (3.89)[c]	12.99 (10.91)
%ODC	19.93 (3.67)	14.77 (9.99)	27.13 (9.73)[d,e]	12.29 (5.68)[c]	8.85 (3.56)[c]	17.04 (9.32)
%PR	16.67 (0.40)	16.62 (0.64)	17.35 (0.46)[e]	16.52 (0.91)	16.08 (0.26)[c]	16.77 (0.70)

Statistically different of P1[a]; P2[b]; P3[c]; P4[d]; P5[e]; and P6[e] for a *p-value* < 0,05

Discussion

In this study it was analysed the patterns of interactions between teammates in volleyball attacking process. The passing sequence it was studied based on social network analysis and the prominence of each tactical position it was analysed using centrality metrics. Two competitive levels (U12 and Amateurs >20 years) were also compared.

In the case of competitive level no differences it were found between centrality levels. In fact, such results may reveal that the structure of attack from the receiving action until the spike may be conditioned by the specific rule of 3-passes. Due such limitation, the orientation of the initial pass to the player in zone 3 and the setting for positions 2 or 4 may constrain the variance between different competitive levels.

In the case of analysis to the tactical positions, it was found that P3 it is the position that more receive passes and pass for teammates. Their centrality levels are statistical different from P1 and P5 in the case of balls received (%IDC), from P4 and P5 in the case of passes for teammates (%ODC) and from P5 in the case of overall prominence (%PR). As possible to observe, P5 are always statistical different in comparison with P3 and this result can be partially explained by the external position in the field. In fact, it was found in a previous study that external positions represents a fewer efficacy in to receive the ball (Afonso et al., 2012), thus compromising the correct pass.

As possible to observe in the descriptive statistics, the P1 and P6 were the following prominent players in receiving the ball. Such results can be associated with the specific tactical positions that perform the receiving and following pass for P3. In the other hand, P2 and P4 were the players that more received more balls, besides P3. These three players are the forward players and for that reason can be considered as the target players to conclude the attacks.

This had some limitations based on the small sample collected from the six matches. For that reason, further studies must increase the overall number of matches and to add some variables such as the inter-dependency metrics. Such metrics will add some value in to identify the dependence of some players from the others and to establish a pattern of interaction. Moreover, will be interesting to split the analysis based on time periods and identify if network patterns may depend from the specific profile of opponents.

Conclusion

This study analysed the influence of tactical position and competitive level in the relationship between teammates in volleyball. The network analysis revealed that P3 position had the biggest values of centrality in to receiving the ball and in to pass for their teammates. By the other side, P5 had the smallest values of passes performed and overall prominence inside the attacking dynamics. With this study it was possible to measure the centrality levels of volleyball players by using the social network analysis.

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