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Original Article

Network properties and performance variables and their relationships with distance covered during elite soccer games

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Abstract
The purpose of this study was to study the relationships between overall distance covered by soccer players and the general network properties and notational variables. Six official games played by a team during the UEFA Champions League were analyzed. The sum of distance covered of soccer players per game was associated with the network density and total arcs and with goals scored, goals suffered, total attempts, ball possession, passes attempts and passes completed. Nearly perfect correlations were found between distance covered and goals suffered (-0.95; 90%CI: -0.99;-0.71). Moderate correlations were found between distance covered and total attempts (0.40; 90%CI: -0.48;0.88), ball possession (-0.35; 90%CI: -0.52;0.87) and passes attempt (-0.35; 90%CI: -0.52;0.87). Small correlations were found between distance covered and passes completed (-0.29; 90%CI: -0.85;0.58), total arcs (-0.14; 90%CI: -0.80;0.67) and network density (0.11; 90%CI: -0.78;0.69). Trivial correlations were found between distance covered and goals scored (-0.07; 90%CI: -0.77;0.71). Results suggest that a higher value of goals suffered are strongly associated with lower level of distance covered. Moreover, teams that covered greater distances are moderately associated with greater values of goals attempts and with smaller values of ball possession and passes completed.
Keywords: digraph theory; network analysis; adjacency matrices; performance analysis; match analysis.

Introduction

Match analysis have been growing in the last decade trying to explain the effects of contextual variables on the team's performance (Sarmento et al., 2014, 2017). Match analysis can be split in the categories of time-motion analysis regarding the specific physical demands that occurs during the game; notational analysis considering the codification of specific outcomes of the team's performance or collective behavior trying to describe some patterns of interactions that emerges from the game (Carling, Williams, & Reilly, 2005; Filipe Manuel Clemente, Martins, & Mendes, 2016; Hughes & Franks, 2004). However, the interactional process between variables detected from different match analysis techniques it should be the most interesting approach to explain the reality of the game (Sarmento et al., 2017).

Contextual or situational performance variables such as match status, match location or quality of opponents have been researched trying to explain the physical demands presented during soccer games (Sarmento et al., 2017). Interesting results revealed that elite soccer players decreases the amount of distance covered at different speed during winning situations (Lago, Casais, Dominguez, & Sampaio, 2010) or that the quality of opponents constraints the physical demands of the team (Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). These comparisons between situational factors revealed that physical demands can be associated with different variables of the game and for that reason a closer analysis was made recently. In this particular, regarding the association between ball possession and physical demands it was found in a study with a sample of 810 players that ball possession did not influenced the teams overall activity profile (Bradley, Lago-Peñas, Rey, & Gomez Diaz, 2013).

Distance covered can be interpreted as an fitness indicator of the players, however is capacity to explain the real physical demands is not too consistent based on the fact that does not consider the intensity of the players (Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010). However, the association of overall distance with specific performance actions and team's behavior have not been deeply analyzed. In particular, the team's collective behavior and the style of play may influence the physical demanding of the team and also the fitness requirements of players (Abdelkrim, Castagna, Fazaa, & Ati, 2010; Bangsbo, Mohr, & Krustrup, 2006).

The collective behavior of teams have been researched using temporal analysis (Bloomfield, Jonsson, Houlahan, & Donoghue, 2005), geometrical analysis/tactical metrics (F. M. Clemente, Sequeiros, Correia, Silva, & Martins, 2017) and social network analysis (Filipe Manuel Clemente et al., 2016). In particular, social network analysis have been used to classify the interactional process between teammates during passing sequences and to classify the overall macro level of the team using measures as total links (arcs) or network density (F.M. Clemente, Martins, Kalamaras, Wong, & Mendes, 2015; Filipe Manuel Clemente, Couceiro, Martins, & Mendes,

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2015). The crossing between social network analysis and notational variables (such as goals scored) revealed that highest values of connectivity of the network is associated with best team's performance (F.M. Clemente et al., 2015). Despite the close relationship studied between network process of the team and overall teams performance measured by notational analysis there is a lack on the literature associating these variables with physical demands. However, such association can be very important to understand how they are related and how coaches can use such information to optimize the training process and fitness levels of the players to react to specific events/moments that occurs in the game. Based on that, the purpose of this study was to analyze the relationships between distance covered, notational and network variables during elite soccer matches in UEFA Champions League 2017/2018.

Methods

Sample

The same elite soccer team was analyzed during six official games during the round-of-all of UEFA Champions League 2017/2018. A total of 2908 passes completed between teammates were recorded and converted in adjacency matrices to build the networks. The cross-sectional study was conducted following the ethical guidelines for the study in humans as suggested by Declaration of Helsinki.

Data Collection

Overall distance covered (sum of all distances covered by team players during each game), weighted adjacency matrices of passes completed between teammates, goals scored, goals suffered, total attempts (shots), ball possession (%), passes attempts and passes completed were obtained through the official website of UEFA Champions League 2017/2018.

Network Analysis

Using the weighted adjacency matrices of passes completed between teammates it was possible to calculate two general network measures: i) arcs (total links); and ii) density (of the network). The adjacency matrices were imported in the software Social Network Visualizer (version 1.9., Greece) and the general measures were executed with the following algorithms for each one.

Arcs

Considering a weighted digraph G of n vertices the arcs index , of G can be computed as (F.M. Clemente, Martins, & Mendes, 2016; Rubinov & Sporns, 2010):

$$L_D^w = \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq i}}^{n} a_{ij}, \quad (1)$$

where a_{ij} are elements of the weighted adjacency matrix of a G.

Network density Considering a weighted digraph G of n vertices, the density , of G can be calculated as (F.M. Clemente et al., 2016; Wasserman & Faust, 1994):

$$\Delta_D^w = \frac{L_D^w}{n(n-1)}. \quad (2)$$

where is the total links index of a G.

Statistical Procedures

The association between distance covered of the team players and the network and performance variables was analyzed with Pearson correlation test. The magnitude of correlations were interpreted as follows (Hopkins, 2002): 0.00-0.09 trivial; 0.10-0.29 small; 0.30-0.49 moderate; 0.50-0.69 large; 0.70-0.89 very large; and >0.90 nearly perfect.

Results

Descriptive statistics of distance covered, network and performance variables can be found on table 1.

Table 1. Descriptive statistics (mean ± SD) of distance covered, network and performance variables.

Variable	Mean ± SD
Team's Distance covered (m)	109820.33 ± 4869.08
Goals scored (n)	0.17 ± 0.39
Goals suffered (n)	2.33 ± 1.30
Total attempts (n)	14.67 ± 7.18
Ball possession (%)	54.33 ± 8.77
Passes attempts (n)	566.50 ± 141.34
Passes completed (n)	484.67 ± 138.47
Arcs (A.U.)	115.50 ± 4.81
Density (A.U.)	0.63 ± 0.02

The associations between distance covered, network and performance were tested with Pearson correlation test (Figure 1). Nearly perfect correlations were found between distance covered and goals suffered (-0.95; 90%CI: -0.99;-0.71). Moderate correlations were found between distance covered and total attempts (0.40; 90%CI: -0.48;0.88), ball possession (-0.35; 90%CI: -0.52;0.87) and passes attempt (-0.35; 90%CI: -0.52;0.87). Small correlations were found between distance covered and passes completed (-0.29; 90%CI: -0.85;0.58), total arcs (-0.14; 90%CI: -0.80;0.67) and network density (0.11; 90%CI: -0.78;0.69). Trivial correlations were found between distance covered and goals scored (-0.07; 90%CI: -0.77;0.71).

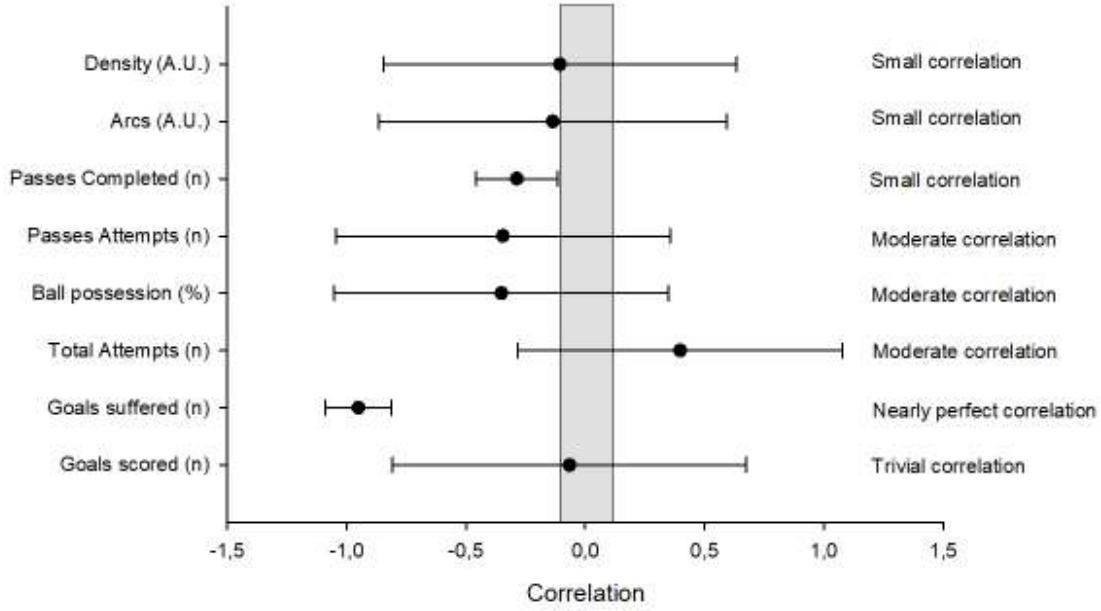

Figure 1. Correlation value (90%CI) of overall distance covered and the network and performance variables.

Discussion

The purpose of this study was to analyze the associations between distance covered and some notational and network measures tested in an elite soccer team during UEFA Champions League 2017/2018. The main results revealed nearly perfect correlations between distance covered and goals suffered. Moreover, moderate correlations were found between distance covered and passes attempts, ball possession and total shot attempts. Passes completed, total arcs and network density were small correlated with total distance. Finally, trivial correlation was found between distance covered and goals scored.

Goals suffered were inverse correlated with distance covered. In previous studies it was found that the winning status lead to a decrease in the intensity of running (Lago et al., 2010). However, the nearly perfect relationship between goals suffered and distance covered revealed that in this particular team that the smaller values of distance covered partially explained the higher number of goals suffered. These results should be carefully interpreted based on the fact that only one team was analyzed and that this great association cannot entirely explain the goals suffered. However, coaches should be aware for the importance of built new training strategies to reply the effects of suffered goals and react with higher physical intensity during the match trying to score. Regarding the moderate relationships between distance covered and ball possession it was found an inverse association suggesting that greater ball possession associates with less distance coverage. Actually, these values does not confirm previous findings that did not found relationships between both variables (Bradley et al., 2013). However, teams that tend to defense more will be constrained in to run more to recover the ball and for that reason it is reasonable to consider that the distance covered will increase as well the opposite. This should be also considered by coaches that must organize the training process considering the team's strategy and fit the fitness level with the playing style of the team.

Inverse relationships between passes attempts and distance covered were also found, suggesting that fewer passes attempts can be associated with greater distances probably looking forward for the counter-attack style that implies great distances in the longitudinal axis of the pitch. In the other hand, passes completed are moderately and positively associated with distance, thus the greater number of passes completed are associated with greater distances. Once again, the style of play will constraint the distance covered and for that reason it is important to optimize the training process mainly considering that more passes completed will increase the movements and actions of the players being important to contribute with a higher aerobic and anaerobic capacity being specific with the playing positions (Boone, Vaeyens, Steyaert, Vanden Bossche, & Bourgois, 2012).

The network processes of the team was small correlated with distance covered, thus suggesting that the total links (arcs) and network density may not constraint or be constrained by the distances covered by the team. However, further researches should be conducted to analyze if individual distance covered may justify the

centrality levels of players in terms of network prominence (Filipe Manuel Clemente, Martins, Kalamaras, Wong, & Mendes, 2015).This study had some limitations. The number of the games are small and only one team was analyzed. However, the contributions and the analyzes of this study are new and future studies should continue the approach using more data and trying to explain the distance covered by speed intensity with some performance variables measured by notational and behavioral analyses.

Conclusions

Main evidences of this study reveals that lower levels of overall distance covered are nearly perfect associated with higher number of goals suffered in this elite soccer team. Moreover, small number of passes attempts and ball possession are moderately associated with greater amounts of distance covered. Finally, higher number of total shots attempts are moderately associated with greater distances covered by team players. Based on that, specific training interventions should consider to adapt the fitness levels of players to the specific match situations that occur during the match trying to optimize the capacity to react to different performance outcomes.

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