Artigo Original

ANALYSIS OF NETWORK PROPERTIES AND TACTICAL BEHAVIOR OF U-17 SOCCER ATHLETES WITH DIFFERENT TACTICAL SKILLS

ANÁLISE DAS INTERAÇÕES E DO COMPORTAMENTO TÁTICO DE ATLETAS SUB-17 DE FUTEBOL COM DIFERENTES CAPACIDADES TÁTICAS

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ABSTRACT

This study aimed compare individual tactical behavior and network properties of players with higher and lower tactical skills during soccer small-sided games. The sample was composed of 18 U-17 elite soccer players (16.2 years old) from the same national level team. Players were divided into group 1 and group 2, with higher and lower tactical skill, respectively, measured by the FUT-SAT. After this, they played 12 small-sided in a 36x27m field with all rules of the formal game. Players' tactical behavior was assessed through the incidence of fundamental tactical principles during the SSG. Total links, density and clustering coefficient were defined as the general network metrics. Data were analyzed through independent t-test and Mann-Whitney test. Results showed that group 1 presented higher values of total links ($p=0.007$) and density ($p=0.007$). Group 1 also presented a higher incidence of defensive unity ($p=0.001$), while group 2 realized more actions of defensive balance ($p=0.008$) and recovery balance ($p=0.038$). We conclude that tactical skills are able to constraint individual team behavior in small-sided games.
Keywords: Football; Task performance and analysis; Physical Education

RESUMO

Este estudo objetivou comparar o comportamento tático individual e as propriedades da rede de interações de atletas com maior e menor capacidade tática durante pequenos jogos no futebol. A amostra foi composta por 19 jogadores de futebol sub-17 (16.2 anos) de um mesmo time, de nível nacional. Jogadores foram divididos em grupo 1 e grupo 2, com maior e menor capacidade tática, respectivamente, medida pelo FUT-SAT. Na sequência, eles participaram de 12 pequenos jogos em um campo de 36mx27m com todas as regras do jogo formal. Avaliou-se o comportamento tático dos jogadores por meio da incidência dos princípios táticos fundamentais durante os pequenos jogos. Total links, densidade e clustering coefficient foram definidos com as medidas das propriedades gerais da rede. Analisaram-se os dados por meio do teste t independente e do teste de Mann-Whitney. Os resultados mostraram que o grupo 1 apresentou maiores valores para total links ($p=0.007$) e densidade ($p=0.007$). O grupo 1 apresentou ainda maior incidência de ações de unidade defensiva ($p=0.001$), enquanto o grupo 2 realizou mais ações de equilíbrio defensivo ($p=0.008$) e equilíbrio de recuperação ($p=0.038$). Conclui-se que a capacidade tática influencia o comportamento individual e coletivo durante pequenos jogos.
Palavras-chave: Futebol; Análise e desempenho de tarefas; Educação Física

Introduction

Soccer players are required to make good decisions during a match in order to achieve good individual and team performance[1,2]. For this reason, the development of tactical skills plays an important role in the teaching-learning process[3] and is deeply related to a good sport performance[4]. These tactical skills represent players' ability to understand and apply game principles[5], which support players' decision-making. Therefore, several authors have proposed the assessment of players' knowledge about game principles as an important part of the teaching-learning process[6–8]. Previous studies[9–11] have used the System of Tactical Assessment in Soccer - FUT-SAT[12] - to analyze players' tactical skills related to Fundamental

Tactical Principles, which represent a set of basic rules that guide the action of players and teams in the two phases of the game[5]. Since the Fundamental Tactical Principles support players' decision-making, athletes' performance on these principles during a game-related situation is an indicator of players' tactical skills.

Different teaching and training approaches in soccer propose the use of small-sided games (SSG) as a strategy to develop players' tactical skills[7,13]. The use of SSG aim to simplify the complex reality of the formal game, modifying some rules while keeping the original format dynamics and avoiding its fragmentation (as in analytic exercises/activities)[14]. The similarities between the acute stimuli generated by the SSG and the formal game[15] are accompanied by the SSG's potential to refine players' perception of the tactical reality and collective behavior[7,16]. The rule modifications and other characteristics adopted during the SSG can make the tactical objectives more explicit and, consequently, increase players' perception[14] while keeping the variability inherent to game dynamics. In this sense, players are induced to solve the same tactical problem several times although the solution is not always the same[17]. Although previous studies allow a broaden understanding about the possibilities do use SSG during the training process in soccer, some specific characteristics of this training tool are still unknown. In this point, the influence of tactical skills – in this study represented by players' performance on the Fundamental Tactical Principles – on players' behavior during game-related situations (*e.g.* SSG) is not well-established in the literature what limits the possibility to use SSG as a conditioning stimuli considering that the desired adaptation can be affected by players' tactical skills, what was not deeply investigated until this moment.

Based on the need to understanding how both players and teams solve tactical problems during games in order to better adjust the training process, the study of team sports dynamics through the observation of players' and teams' behavior patterns is long-established[9] and resulted in the development of different observational techniques. Besides the use of the previously mentioned FUT-SAT[12], new methods have been tested in order to give support to game analysis and sports phenomena[18,19]. The Social Network Analysis (SNA) is a technique that uses graphs to interpret how players interact as in a network[20]. The SNA present general and centrality measures, which allow the identification of team cooperation properties as well as the prominence of each player in the collective strategy[21]. For team analysis, variables such as the total links and the network density have been adopted to calculate players' connectivity and general affection[22]. Although these variables have not been analyzed in SSG, they enable the investigation on the effect of SSG characteristics on players' behavior and also complement the information given by the observational methods previously described in the literature[23].

In this context, there is a gap on the influence of the tactical skills of the players in their behavior during SSG in the literature. Since coaches need to adapt the teaching-learning process to players' needs, it is important to understand how players' tactical skills might affect their behavior. Therefore, this study aimed to compare the tactical behavior and general network properties of U-17 soccer athletes with higher and lower tactical skills – represented by the percentage of correct actions related to the Fundamental Tactical Principles.

Methods

Participants

Non-probabilistic sampling was used for selection of the sample. Eighteen young male soccer players (age: 16.2± 0.9 years – six defenders, six midfielders, and six forwards), members of a Brazilian elite team. They participated in national and federated competitions,

and had a mean experience of 4.4 years. Their standard training schedule includes 6-8 sessions per week (with an approximate duration of 90 minutes), and additional competitive games. Players' regular training sessions were not altered or controlled during the data collect. The Ethics Committee of Universidade Federal de Minas Gerais approved this study (CAE 51011915.9.0000.5149). All participants and their legal guardians provided free informed consent.

Procedures

Since the independent variable is the players' tactical skills, the first procedure performed was the field test of the System of Tactical Assessment in Soccer - FUT-SAT[12] (details are available in the following section), which enabled the division of the players into two groups: group 1 (G1) composed by the nine players with higher tactical skills and group 2 (G2) composed by the other nine players with lower tactical skills. Within each group, three teams were composed and kept along the whole data collect. Each team included one defender, one midfielder and one forward (see Figure 1).

Group 1			Group 2		
Team	Position		Team	Position	
A	D^1	M^3	F^2	**D**	D^4	M^6	F^5
B	D^2	M^1	F^3	**E**	D^5	M^4	F^6
C	D^3	M^2	F^1	**F**	D^6	M^5	F^4

Figure 1. Team composition and group division
Note: Positions: D= Defender; M= Midfielder; F= Forward. Superscript numbers indicate player's ranking on each position.
Source: Own Source

During the subsequent sessions, athletes played the SSG within groups 1 and 2. The 3vs.3 SSG was chose for investigation because it allows all the decisional possibilities present in the formal game[12]. The SSG were played on a 36x27 meters field area with two goals sized 5x2 meters[7,24]. All experimental sessions occurred at the same time of the day to standardize the effect of the circadian rhythm[25]. The rules were the same as in the formal game, including the offside rule. Each session started with a 10-minute warm-up, comprising actions with and without the ball (without opponents) and typical soccer movements.

During data collect athletes did not participate of any official matches. The SSGs were played as two 4-minute bouts within each group. Teams from group 1 did not play against teams from group 2, in order to reduce the influence of the level of the opponent on players' behaviors[26].

Independent Variable: tactical skills

Players' tactical skills were assessed using the System of Tactical Assessment in Soccer – FUT-SAT[12]. It consists of a 4-minute 3vs.3 game with all soccer rules, played on a field area of 36x27m. The FUT-SAT protocols were filmed for further analysis. To record the SSGs to the further analysis, a JVC Everio GZ-HD520 digital camera was used.

The athletes' tactical skills were assessed within the Observation Macro-category, which includes 5 tactical principles related to the offensive phase – penetration, defensive coverage, width and length, depth mobility and offensive unity - and 5 tactical principles related to the defensive phase - delay, defensive coverage, balance, concentration and defensive unity[12]. The final index was calculated as the percentage of positive tactical actions, as expressed in the equation:

$$\frac{\text{Total number of positive tactical actions}}{\text{Total number of tactical actions}}$$

Finally, group 1 was composed by the nine athletes with higher tactical skills, while group 2 was composed by the nine athletes with the lower scores. An independent t-test confirmed the difference between G1 and G2 in the variable used to split them these groups (t=13,66; p=0,007).

Dependent Variables
Tactical Behavior

The SSG bouts were filmed and athletes' tactical behavior was assessed using the System of Tactical Assessment in Soccer – FUT-SAT[12]. Then, athletes' individual incidence of the tactical principles was evaluated.

General Network Properties

This study followed an observational protocol for network analysis. An adjacency matrix was used for each offensive process, following the recommendations for weighted diagraphs analysis[17]. In team sports, information about the number and direction of the passes is important to understand teams' dynamics. Therefore, an adjacency matrix was built for each unit of attack, which was considered a passing sequence without losing the ball) (Passos et al., 2011). A value of 0 was used to codify the relationship between dyads, which were considered the cases of no passes between teammates or the number of passes made in the same direction (i.e. 2 passes from player A to player B and 3 passes from player B to player A). For each game, a total adjacency matrix was computed (the sum of all units of attack that occurred in the game).

An adjacency matrix of each game was obtained and then processed in Social Network Visualizer (SocNetV). This software is used to visualize and analyze graphs and digraphs for social network analysis. Total links, network density and clustering coefficient were used as general measures of the network.

The Total Links can be defined as the absolute and non-repeated number of total interactions conducted between teammates during a match[17]. Greater values represent a stronger cooperation among all teammates. Network density measures the overall affection between teammates and represents the proportion of the maximum possible links present between nodes[17]. Values vary between 0 (no density) and 1 (maximal density and affection). Finally, the clustering coefficient indicates how close a player and its teammates are in a graph to become a clique. In teams sports it is possible to observe a higher average clustering coefficient compared to random networks, which proves their clustering nature[17].

Statistical Analysis

Data related to the network properties and tactical performance were initially analyzed regarding the normality of the distribution (Shapiro-Wilk's test) and variances homocedasticity (Levene's test). Non-parametric procedures – Mann-Whitney U test - were performed when any of these assumptions were not assumed (Clustering Coefficient). An independent t-test was used to compare the data related to the Total Links and Density in the SSG performed by the groups 1 and 2.In both cases, Cohen's d effect size was calculated and considered small (d<0.2), moderate (0.2<d<0.6), big (0.6<d<1.2), very big (1.2<d<2.0), or nearly perfect (2.0<d<4.0)[27]. Data related to the fundamental tactical principles incidence were analyzed using the proportions chi-square test. Omega effect size (ω) was calculated and

classified as small (ω smaller than 0.1, or 1% of total variance), medium (ω between 0,1 and 0,3, or 9% of total variance) or big (ω bigger than 0.5, or 25% of total variance)[28].

The statistical analyses were carried out using the software SPSS (SPSS Version 20.0 for Windows, SPSS Inc., Chicago, IL, USA). The Cohen's d effect size was calculated using the software GPower 3.1.7 (Franz Faul, Universitat Kiel, Germany). Statistical significance was set at 0.05.

Data Quality

As recommended in literature[29], 12.5% of the SSG were reassessed (3out of 24 SSG) after 21 days[30]. The Kappa of Cohen coefficient and its standard error was calculated for the incidence of the Tactical Principles and Passes (network analysis). Values greater than 0.879 (SE=0.013) and 0.863 (SE=0.013) were found for intra and inter observer reliability, respectively, indicating a perfect agreement[31].

Results

Table 1 presents the incidence of tactical principles performed by athletes with higher (group 1) and lower (group 2) tactical skills. During the SSG, 4945 (±68.6 per player) tactical actions were performed. Players from group 2 performed more defensive balance actions (χ^2= 7.000; p= 0.008; medium effect) and recovery balance (χ^2= 4.309; p= 0.038; medium effect) while athletes from group 1 performed more actions of offensive unity (χ^2= 17.363; p= 0.001; big effect). Results indicate that players' tactical skills influences the incidence of fundamental tactical principles, although only moderate effect sizes were reported (except for defensive unity). This can indicate some biases, like physical level of the players (for example) on the reported results.

Table 1. Incidence of fundamental tactical princles during the SSG

Variable	Group 1	Group 2	p-value	Effect Size
Offensive Principles				
Penetration	149	165	0.367	0.1064
Offensive Coverage	235	270	0.119	0.1836
Width and Lenght	401	364	0.181	0.1577
Width and Lenght (with the ball)	39	44	0.583	0.0647
Depth Mobility	91	70	0.098	0.1950
Offensive Unity	260	265	0.827	0.0258
Defensive Principles				
Delay	228	226	0.925	0.0112
Defensive Coverage	98	121	0.120	0.1832
Defensive Balance	147	196	0.008*	0.3118
Recovery Balance	96	127	0.038*	0.2446
Concentration	130	142	0.467	0.0857
Defensive Unity	609	472	0.001*	41.669

Note: * Significant diferences (p<0.05)
Source: Own source

Table 2 presents the general network properties of the SSG performed by the players within groups 1 and 2. Group 1 presented higher values of total links (T=3.313; p=0.007; very big effect) and density (T=3.314; p=0.007; very big effect). Although no significant differences were reported on the Clustering Coefficient, a big effect size was found, indicating a possible influence of the tactical performance on this variable. In summary, results indicate that players with higher tactical skills adopted a more cooperative behavior during the investigated SSG.

Table 2. General network properties of athletes with higher (group 1) and lower (group 2) tactical skills

	Density	Total Links	Clustering Coefficient
Group 1	0.93 (0.082)	11.166 (0.983)	0.874 (0.164)
Group 2	0.749 (0.105)	9 (1.264)	0.742 (0.099)
p-value	0.007[*]	0.007[*]	0.124
Effect Size	1.920	1.910	0.974

Note:[*]Significant differences (p<0.05)
Source: Own source

Discussion

The aim of this study was to compare the tactical behavior and the general network properties U-17 soccer players with higher and lower tactical skills during SSGs. The main results indicate that soccer players with higher tactical skills presented significantly higher values of density and total links, and differences in the incidence of defensive tactical principles were also reported. This study also promoted important insights about the usefulness of Social Network Analysis to investigate players' behavior in training situations, such as small-sided games, what was not previously proposed on the literature.

The influence of players' tactical knowledge on players' behavior has been previously investigated[7]. In this study, players' tactical knowledge was considered as players' performance on the fundamental tactical principles assessed by the FUT-SAT[12], what is considered suitable because the relevance of the fundamental tactical principles on the time and space manangement during a soccer game[32]. In this sense, the reported differences in the incidence of tactical principles within players of each group reinforce the influence of tactical knowledge on tactical behavior, what indicates that the knowledge about the game results in new possibilities of action. This rationale is in line with the suggestion of a bidirectional link between cognition and action[33,34]. Specifically, considering that the defensive moment of the game demands from the players cohesion and interpersonal coordination in order to induce the opponent team to a less favorable place on the field to obtain goals[7], and the importance of defensive unity to allow the team to defend as an unity[35], the higher incidence of defensive unity in group 1 indicates that players with higher tactical skills tend to adopt a more cooperative defensive behavior. This suggestion is reinforced by network properties investigated in this study and discussed below.

It has been suggested in the literature that the interpersonal coordination – a key factor to establish cooperation relationships – emerges from sharing plans of action and decision-making between players[4]. Considering that decision-making is oriented by players' tactical knowledge[1]- which is associated to the knowledge about the tactical principles[5,35] – the latter represents an important factor to increase the interactions between players. The greater number of connections (Total Links) and its density in the SSG performed by the athletes

with higher tactical knowledge confirmed this hypothesis in the present study. This supports the tactical performance as a determinant factor of players' general affection during offensive process in SSG. Considering the training process in soccer, these results can imply in two information to coaches. Firstly, if a game model based on supported attack is desired, seems to be mandatory to develop players' tactical skills in order to allow them to adopt a more cooperative behavior. Since this more cooperative behavior is strongly based on players' ability to create space and identify good opportunities to pass the ball – which is understood as the formal link between players[36] -, the development of fundamental tactical principles of width and length and offensive coverage must be focused.

The influence of athletes' physical attributes on individual and team tactical performance was not investigated in this study and represents a potential limitation. Therefore, future studies should consider verify the effect of physical conditioning on tactical performance. Furthermore, future studies should verify the association between declarative tactical knowledge and tactical performance measured with FUT-SAT, since models of cognitive architecture suggests the relationship between these constructs[37]. Besides this, one must be careful when analyzing the results with the average effect size. In this context, the results are valid, but it must be pointed out that there is possibility of interference of other variables in the results.

Despite these limitations, this study was the first to present that the individual tactical performance is able to constraint individual and team' behavior and that SSG can be conditioned by the quality of players in the teams. This issue can also be discussed by coaches, especially with respect to the necessity of splitting players according their learning needs.

Conclusion

In summary, this study found that players with higher tactical skills presented greater values of network density and total links. It was also showed differences on the incidence of defensive fundamental principles. Based on these results, it is possible to conclude that individual tactical knowledge and behavior may constraint the collective efficacy and players' tactical behavior during SSG.

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