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THE EFFECT OF AGE ON THE COLLECTIVE BEHAVIOR OF FOOTBALL PLAYERS IN SMALL-SIDED GAMES

Dissertação elaborada com vista à obtenção do Grau de Mestre em Treino de Alto Rendimento

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TABLES OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The main goal of this study was to analyze how the offensive and defensive collective behaviors performed in six-a-side game (GK+5 v. 5+GK) vary according to the age and expertise level of young football players (U16, U17 and U19). For this purpose, four measures of collective performance (*surface area*, *stretch index*, *length* and *width* of a team) have been analyzed. Thirty-six male young football players of three age groups participated in the study (U16 - playing experience: 6 ± 1,76 yrs; U17 - 7 ± 1,4 yrs; U19 - 8,7 ± 2,8 yrs). Each group was divided in two balanced teams, which played during 8 mins, with field dimensions of 33m x 60m (165m2 per player). Ten GPS units (GPSports systems SPI PRO) were used to collect the 2D movement displacement trajectories of players. MATLAB software was used to calculate specific team's behaviors. Sample entropy *(SampEn)* analysis demonstrated that the regularity of variation of *surface area* and *team width* in offensive phase and *team length* and *width* in defensive phase varied significantly according to the players' age and expertize. Pearson correlation coefficients (r) suggest that players' dispersion, measured by *surface area* and *stretch index*, was strongly and negatively correlated in attack and defense. Our findings demonstrated that the age and expertise level of players influence their collective behavior in SSGs. It was concluded that compound positional variables might be considered as a valuable tool to understand the teams' behavior in offensive and defensive phases of small-sided games.

Keywords: *small-sided games; association football, compound positional variables, young football players, expertise, GPS, sample entropy*

RESUMO

O presente estudo teve como objetivo analisar a variabilidade do comportamento tático coletivo ofensivo e defensivo num jogo reduzido de futebol (GR +5 *vs.* 5 + GR) em função da idade e nível de experiência dos jogadores dos escalões de formação sub-16, sub-17 e sub-19. Quatro variáveis posicionais foram utilizadas para analisar o comportamento coletivo dos jogadores: *área de superfície*, *índice de dispersão*, *comprimento de equipa* e *largura de equipa*. No estudo participaram 36 futebolistas masculinos dos três grupos etários (sub-16 - experiência competitiva: 6 ± 1,76 anos; sub-17 - 7 ± 1,4 e sub-19 - 8,7 ± 2,8). Cada grupo foi dividido em duas equipas que jogaram durante oito minutos num campo com dimensões de 33m x 60m (165m^2 área por jogador). Dez unidades de GPS (GPSports systems SPI PRO) foram utilizadas para registar as trajetórias de deslocamento dos jogadores em duas dimensões. Para o cálculo das variáveis posicionais foram utilizadas as rotinas específicas de *MATLAB*. A análise da entropia amostral (*SampEn)* demonstrou que a regularidade das séries temporais da *área da superfície* e da *largura da equipa* na fase ofensiva, tal como do *comprimento* e da *largura da equipa* na fase defensiva diferiam significativamente em função do grupo etário dos jogadores. O coeficiente de correlação de Pearson (*r*) revelou uma forte e negativa correlação entre a dispersão dos jogadores no ataque e na defesa, caracterizada por *área de superfície* e *índice de dispersão*. Os resultados do estudo comprovam que a idade e experiência dos futebolistas influenciam o seu comportamento coletivo em jogos reduzidos de futebol. Ficou concluído que as variáveis posicionais representam uma boa ferramenta para compreender o comportamento coletivo dos praticantes em jogos reduzidos.

Palavras-chave: *jogos reduzidos; futebol, variáveis posicionais compostas, jovens jogadores de futebol, experiência, GPS, entropia amostral*.

1. INTRODUCTION

The use of small-sided games (SSG's) is a common practice in the training of football players of different ages and levels (Hill-Haas Coutts, Rowsell and Dawson, 2008; Duarte et al., 2010; Hill-Haas, Dawson, Impellizzeri and Coutts 2011). These popular training drills offer many advantages in specific skills and provide both physiological and tactical development of players (Hill-Haas, Dawson, Impellizzeri and Coutts 2011; Frencken, Lemmink, Delleman and Visscher, 2011; Sampaio, Lago, Gonçalves, Maçãs and Leite, 2013). Previous studies have pointed out that SSG increased players' game practice time. It is assumed that the time spent on these types of activities could be defined as deliberate practice experience and should play an important role in youth football training programs (Hill-Haas Dawson, Coutts and Rowsell, 2009; Katis and Kellis, 2009; Folgado, Lemmink, Frencken and Sampaio, 2012). The vast majority of studies conducted in this field of research have focused on the physiological determinants of SSGs (Owen, Twist and Ford, 2004; Rampinini et al., 2007), physical and motor responses (Hill-Haas, Dawson, Coutts and Rowsell 2009; Casamichana and Castellano, 2010), as well as on technical and tactical performance of players (Hill-Haas, Dawson, Coutts and Rowsell, 2009; Dellal, Chamari, Owen, Wong, Lago-Penas and Hill-Haas, 2011). In recent years, the study of teams' tactical behavior in SSG is being based on the dynamical information about the players' positioning and coordination (Frencken, Lemmink, Delleman and Visscher, 2011; Folgado, Lemmink, Frencken and Sampaio, 2012; Sampaio and Maçãs, 2012; Sampaio, Lago, Gonçalves, Maçãs, Leite, 2013). According to Hughes and Bartlett (2002), tactical performance indicators in invasion games such as football seek to reflect the relative importance of teamwork, pace, fitness and movement. Players' behavior on the pitch has a high degree of variability, being dependent of the interaction between teammates, opponents and ball possession (Davids, Araújo, and Shuttleworth, 2005; Folgado, Lemmink, Frencken and, 2012), which makes it difficult to fully understand using notational or motion analysis procedures based on individual measures.

With the purpose to understand the interaction between teammates and each team, the recent researches about to the collective behavior in football commonly use the compound positional variables, such as: *surface area* (Frenchen, Lemmink, Delleman and Visscher, 2011; Duarte, Araújo, Freire, Folgado, Fernandes and Davids, 2012), *stretch index* (Bourbousso, Sévec and Mcgarry, 2010; Duarte, Araújo, Freire, Folgado, Fernandes and Davids 2012; Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012), *team width and length* (Sampaio and Maçãs, 2012; Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012; Fradua, Zubillaga, Caro, Fernandez-García, Ruiz-Ruiz and Tenga, 2013), *length per with ratio (lpwratio)* (Folgado, Lemmink, Frencken and Sampaio, 2012) and *distances between team's centroids* (Folgado, Lemmink, Frencken and Sampaio, 2012; Duarte, Araújo, Freire, Folgado, Fernandes and Davids, 2012; Sampaio and Maçãs, 2012; Sampaio, Lago, Gonçalves, Maçãs and Leite 2013). These variables reflect the players' disposition on the field and their interaction with teammates and opponents.

In an exploratory study Frencken and Lemmink (2008) analyzed the collective behavior using the *centroid* and *surface area* measures of two competing football teams in a five-a-side game (GK+4 v. 4+GK). The results of the study confirmed that both *centroid* and *surface area* could be considered as promising variables to describe the flow of the game, players' coordination and goal-scoring opportunities. Later, Frencken, Lemmink, Delleman and Visscher (2011), identified a crossing of the attacking team's centroid positions, over the defending team centroid in forward-backward direction in 53% of the goals scored in SSG. In the same scope of research, Duarte, Araújo, Freire, Folgado, Fernandes and Davids (2012), examined emergent coordination processes in collective patterns of players' behavior in four-a-side game (GK+3 v. 3+GK) near the scoring zone. The authors identified the coordination patterns for *centroid* and *surface area* of each team. The *distance of the centroid* of each team demonstrated that both teams moved forward and backward in a highly synchronized spatiotemporal manner and that reflected the coordinated activity of attackers and defenders near the goal area. The analysis of relationship between *surface areas* of teams did not reveal a clear coordination patterns

between attacking and defending players, however the difference in the occupied area between the attacking and defending teams was significantly increasing over time. Findings emphasized that major changes in collective behaviors of each team occurred just before an assisted pass was made (i.e., leading to a loss of stability in the four-a-side game). The results of this study have demonstrated how interpersonal coordination processes within and between two teams of competing football players can be captured by compound positional variables that synthesized the functional relationships between individuals and the performance environment.

The study of Frias (2011) aimed to analyze the influence of the variation of the defensive play method on the players' collective behavior in a six-a-side game (GK+5 v. 5+GK). The SSG were performed in two experimental conditions (zone and man-to-man defense). The teams' behavior was captured by four compound positional variables: *surface area, stretch index, lpwratio* and *teams' centers distance*. Concerning zone and man-to-man defensive playing methods results showed that zone defense appeared to be a more organized and less willing to opposing team initiatives. Also, lower variability gives zone defense an economic character that can result important in practice. The results clearly confirmed hypothesis that the defensive method influenced teams' collective behavior.

Sampaio and Maçãs, (2012) used dynamic positional data of players to assess tactical behavior by measuring movement patterns and inter-player coordination. A pre and post-test design was used to assess the effects of a 13-week constructivist and cognitivist' training program by measuring behavior in a 5-a-side game. Their data was captured at 5 Hz by GPS devices (SPI Pro, GPSports, Canberra, Australia) and analyzed with non-linear signal processing methods. Approximate entropy values were lower in post-test situations suggesting that these time series became more regular with increasing expertise in football. In another study Sampaio, Lago, Gonçalves, Maçãs and Leite (2013), compared time-motion variables, heart rate and players' tactical behavior according to game pace (slow, normal or fast), match status (winning and losing) and team unbalance (superiority and inferiority) in football five-a-side games. It was concluded that the dynamic positional data of players' performances could be used as a tool to evaluate the players' adaptive behavior to dynamic environmental conditions.

Several studies confirmed that, in the scope of a constraints-led approach, the game format (pitch size, number of players and rules' modifications) has implications on the individual and collective actions performed by players (Duarte, *et al.*, 2010; Ford and Williams, 2012; Almeida, Ferreira and Volossovitch, 2013). Nevertheless, it is still not clear how players of different ages and playing experience behave in analogous practice tasks, if their performances are similar and, if not, how the differences could be explained. With the exception of the study of Folgado, Lemmink, Frencken and Sampaio (2012), the compound positional variables were predominantly used to describe the collective behavior of adult players. Folgado, Lemmink, Frencken and Sampaio (2012), analyzed and compare the performance of three different age groups of young football players (under-9, under-11 and under-13) in two SSG's format (GK+3 v. 3+GK and GK+4 v. 4+GK). The *lpwratio* and *teams' centroid distance* were used to analyze the teams' movement patterns. The results suggested that the level of players' experience influenced the team's tactical collective behavior. It was noted that the distribution of younger players on the field was characterized by a higher ratio of length and smaller width, as well as by a reduced distance between the geometric centers of the teams. It was concluded that players of different ages have not responded in similar way to the changing of SSG format, demonstrating different tactical behavior. The influence of level of experience, have shown that the more experienced players have better perceptive and cognitive skills and that the decision process is closely related with the structure of collective pattern, which depends on the indications, directions and relative positions of the players surrounding (Poplu, Ripoll, Mavromatis and Baratgin, 2008; Folgado, Lemmink, Frencken and Sampaio 2012; Sampaio and Maçãs, 2012). This aspect furthermore enhances the importance to study and understand the collective tactical implications of different

SSG conditions and their roles in football practice.

Given the scarcity of knowledge about tactical implications on different age and expertise level, the present study aims to analyze how the inter-team coordination of players of three different age groups (U16, U17 and U19) varies in offensive and defensive phases of six-a-side game (GK+5 v. 5+GK). In order to better understand the influence of the age and level of expertise on the collective behavior of young football players in SSGs, the following compound positional variables have been used: *surface area; stretch index; length and width of a team*.

2. METHODS

2.1. Participants

Data were collected from a convenience sample of thirty-six male young football players of three different age groups (under-16 (U16), under-17 (U17) and under-19 (U19). Each group consisted of 12 players (10 players and 2 goalkeepers), whose characteristics are shown in Table 1. The selection of players was made by the coaches and based on the assessment of players' technical and tactical performance in official matches. The players with better results were selected to participate in the study.

Table 1. Characteristics of study participants (mean ± SD)

Age group	**Age** (years) *mean ± SD*	**Height** (m) *mean ± SD*	**Weight** (kg) *mean ± SD*	**Body mass index** (kg/m^2) *mean ± SD*	**Playing experience** (years) *mean ± SD*
U 16	15.2 ± 0.4	1.74 ± 0.03	62.6 ± 4.2	20.7 ± 2.2	6 ± 1.76
U 17	16.3 ± 0.5	1.78 ± 0.04	67.5 ± 4.05	21.3 ± 1.9	7 ± 1.4
U 19	17.4 ± 0.5	1.80 ± 0.07	69 ± 5.8	21.1 ± 2.1	8.7 ± 2.8

2. 2. Procedures

Each age group was divided into two balanced teams. One goalkeeper, two defenders, two midfielders and one forward participated in the six-a-side games. The game system, the teams' composition and the playing positions of the participants were the same across all experimental sessions and also respected the positions normally used by players in training and competition. The absence of an effective member of a group in one of the sessions, due to illness or injury, was filled by the entry of a player substituent from the same age group and corresponding position following the same evaluation criteria. The three groups of participants completed three independent sessions separated by one-week intervals. Each age group of players participated in three six-a-side games. All SSGs were played in the same artificial grass facilities at the beginning of a normal training session, after a six minutes warming-up period. A six-a-side game (GK+5 v. 5+GK) was played during eight minutes on a 33m x 60m (width-length) pitch with $165m^2$ area per player. The official football rules have been implemented with the exception of the offside rule and goalkeepers have been limited to two-touch play with their feet. The movement displacement trajectories (2D) of players have been registered using ten units of the Global Positioning System (GPS) – (SPI PRO tracking system, GPSports, Canberra, Australia). The GPS units were fitted to the upper back of each participant using an appropriate elastic harness. Positional data, speed and distance covered were recorded at 15 Hz throughout each session. All devices were placed on individuals' backs just before the start of the warm-up, so to the players were familiarized with the use of the devices. After the training session, positional data were transferred to excel files using the software Team AMS R2 2010 (GPSports, Canberra, Australia) that connected each of GPS devices for downloading the players coordinates. Each game resulted in 7000 data points for each player in the x- and y- component of motion. Validity and reliability of these instruments had already been proved by the manufacturers and independent verifications (Coutts and Duffield, 2010; and Gray, Jenkins, Andrews, Taaffe, and Glover, 2010). The data recorded by the GPS (spatial x and y positions and speed of players displacement) was exported to MATLAB R2009b for to convert the positional coordinates of the players from degrees to meters and calculate the compound variables that characterize the collective tactical behavior. A total of 302 attacking and 302 defending episodes were selected manually from nine SSG's performed by of each group.

The experimental protocol was approved by the Ethics Committee of the Faculty of the leading author of this study. Players and their parents were fully informed about the aims and procedures of the study and signed an informed consent form.

2. 3. Measures

Four compound positional variables were calculated for each team during the SSGs: *surface area*, *stretch index*, *team length* and *width* (see **Figure 1**). As it was proposed by some studies (Lames, Erdmann and Walter, 2010, and Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012), the collective measures of performance were calculated only for five outfield players of each team, excluding the goalkeepers.

Surface area was calculated using a Matlab function (convhull) that creates a convex polygon from a given number of points (in this case we used a maximum number of 5 points corresponding to the 5 outfield players of each team) and returns the sorted points that compose the polygon and the polygonal surface area for each time frame (Frencken and Lemmink, 2008; Frencken, Lemmink, Delleman and Visscher 2011; Frias 2011, Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012, and Duarte, Araújo, Freire, Folgado, Fernandes and Davids 2012). This variable expresses the relationship between the forms and spaces of both teams and how they vary over time during the game.

Stretch index measures the expansion or contraction of space in the longitudinal and lateral directions that a team demonstrated as the game unfolded (Bourbousson,, Sévec and Mcgarry 2010). This variable was calculated using the mean distance from each player position to the geometrical center of the corresponding team center. Thus, the stretch index represents the mean deviation of each player in a team from the spatial center (Yue, Broich, Seifriz and Mester, 2008; Bourbousson, Sévec and Mcgarry 2010; Frias , 2011, and Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012).

Team width represents the maximum width of a team, calculated as the difference between the maximum and minimum positions of players in the field's lateral dimension in each time frame (Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012).

Team length represents the maximum length of a team, calculated as the difference between the maximum and minimum positions of players in the field's longitudinal direction in each time frame (Duarte, Araújo, Folgado, Esteves, Marques, and Davids, 2012). All computations were developed using dedicated routines implemented in MATLAB R2009b software (The MathWorks Inc, USA).

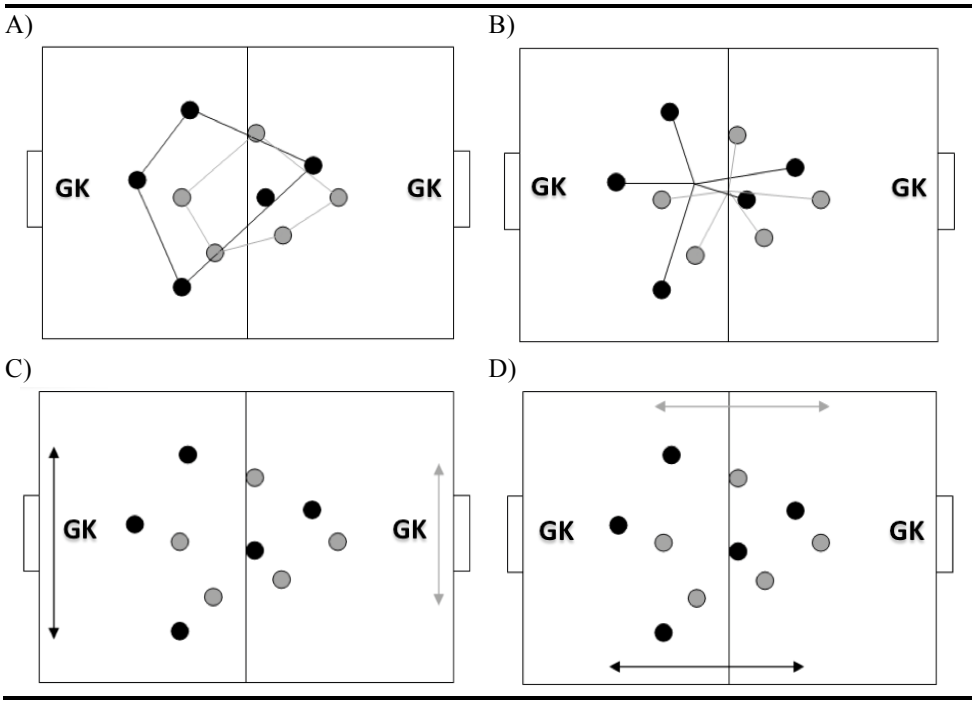

Figure 1. The illustration of the four compound positional variables: A) *surface area*; B) *stretch index*; C) *team length*; D) *team width*

2. 4. Data analysis

Sample entropy (*SampEn*) measures were used to assess the complexity of the particular collective behaviors during the defensive and offensive team phases. *SampEn* (m, r, N) is the negative logarithm of the conditional probability that two sequences similar for m points remain similar at the next point, where self-matches are not included in calculating the probability. Thus, a lower value of *SampEn* also indicates more self-similarity in the time series. *SampEn* is largely independent of record length and displays relative consistency under circumstances where approximate entropy (*ApEn*) does not (Richman and Moorman 2000). In addition to eliminating self-matches, the *SampEn* algorithm is simpler than the *ApEn* algorithm, requiring one-half as much time to calculate. *SampEn* measures the presence of similar patterns in a time-series revealing the nature of their intrinsic structure of variability. Given a series, Y (t), of T points (t = 1, . . ., T), *SampEn* measures the logarithmic probability that two similar sequences of m points extracted from Y(t) remain similar (i.e., within tolerance limits given by r) in the next incremental comparison (i.e., for m+1 sequences). Values close to zero were indicative of regular/near-periodic evolving behavior, while the higher the *SampEn*, the more unpredictable the patterns (Preatoni, Ferrario, Donà, Hamill, and Rodano, 2010).

To evaluate changes in the complexity/regularity of the four compound positional variables according to age/expertise level in offensive and defensive phases across the six-a-side games, distributions of *SampEn* were analyzed using two-way mixed-model ANOVA analysis. When significant effects were found, Games-Howell post-hoc comparisons were applied. Effect sizes were reported as eta partial squared (η^2).

To measure the strength and direction of a linear relationship between the variation of compound variables (*surface area*, *stretch index*, *team width and team length*) in offensive phase of one team and defensive phase of other team during the game course, Pearson correlation coefficients (r) were calculated for the first 30 seconds of each ball possession for three age

groups (U16, U17 and U19). Analyses were performed using IBM SPSS Statistics 20.0 (SPSS Inc., Chicago, USA). Significance level was set at 5% for all statistical procedures.

3. RESULTS

3. 1. Pearson correlation analysis

The values of Pearson correlation coefficients have pointed out a significant negative relationship between all compound positional variables recorded during the first 30 seconds of each ball possession in offensive and defensive phases for all age groups, with exception to *team length*, as could be seen in **Table 2**.

Table 2. Pearson correlation coefficients for four compound positional variables (*surface area, stretch index, team width and team length*) of three age groups (U16, U17 and U19).

Age group	*surface area*	*stretch index*	*team length*	*team width*
	r attack vs. defence	*r* attack vs. defence	*r* attack vs. defence	*r* attack vs. defence
U16	- 0.789*	- 0.575*	0.025	- 0.759*
U17	- 0.787*	- 0.823*	- 0.876*	- 0.178*
U19	- 0.441*	- 0.473*	- 0.502*	- 0.598*

* Significant at 0,01

Pearson correlation coefficient for the time series of *surface area* revealed the high negative relationship between the areas occupied by each team (player's dispersion on the field) in attack and defence for U16 and U17 groups (see **Table 2** and **Figure 2A** and **2B**)). It means that while the area occupied by attackers increases, the area occupied by defenders decreases, particularly during the last 20 seconds of possession.

The U19 group has shown a moderate negative correlation between the *surface area* occupied by players in attack and defence. It was observed that initially the changes of offensive and defensive *surface areas* of U19 displayed a similar pattern to the younger groups (U16 and U17); however, with the progress of ball possession the attacker's and defender's areas became more closed, demonstrating the progressive increasing of the defender's *surface area*, as well as decreasing of attacker's *surface area* (see **Table 2** and **Figure 2C**).

The data also indicates the significant negative correlation between offensive and defensive *stretch index* for all age groups. In the U17 group the highest negative correlation (*r*=-0,75) has been observed between the players dispersion in attack and defence. Younger players (U16 and U17) demonstrated the increasing of the difference between attackers and defenders dispersion as the game unfolded (see **Table 2** and **Figure 2D**), while in the oldest group of players this relationship has been noted only at the beginning (the first 10 seconds) and near the end (the third 10 seconds) of possessions. In the last part of possessions the oldest players revealed higher players' dispersion in defence than in attack (see **Table 2** and **Figure 2F**).

The significant negative correlation between offensive and defensive *team length* has been noted only for the elder groups of players (U17 and U19). At the beginning of possessions the longitudinal displacements of attackers and defenders were similar (the increase of the offensive team length was accompanied by an increase of length of the defence team (see **Table 2** and **Figure 2I**), but as the possessions unfolded, the distance between attack and defence *team length* became increasing, especially for U17 group,

The similar results were observed for the relationship between *team width* of offensive and defensive teams. In the attack the lateral players' dispersion has been increasing over time of possession, while in the defence the *team width* has been decreasing in U16 and U17 groups. In this case the significant negative correlation has been observed for all age groups, but the difference between offensive and defensive *team widths* was smaller over time and several

oscillations in lateral displacement of both teams have been observed (see **Table 2 and Figure 2I**).

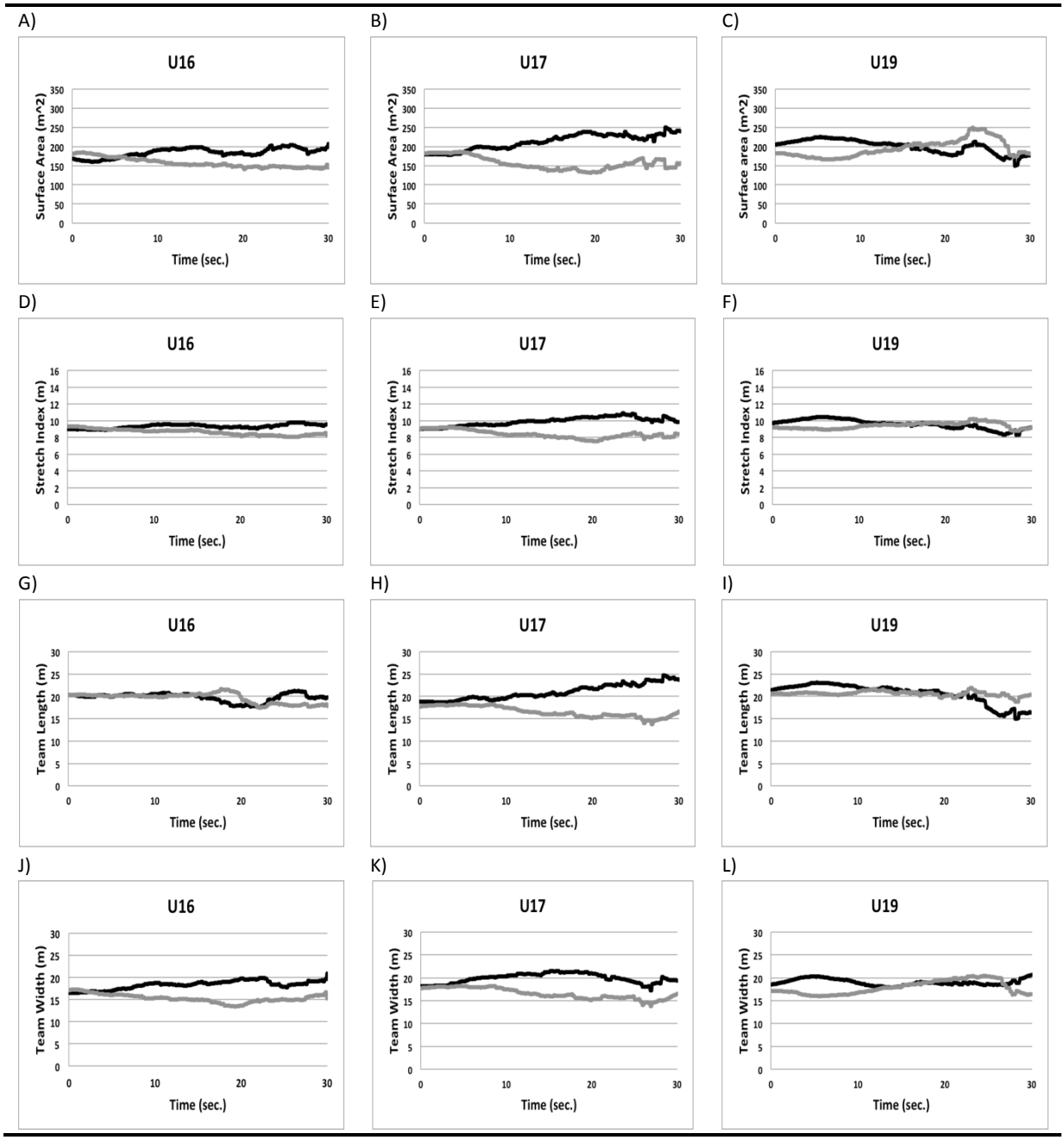

Figure 2. Average time series data recorded during the first 30 seconds of 302 possession in a six-a-side game for the four positional compounds variables: *surface area* (with A) U16, B) U17, C) U19); *stretch index* (with D) U16, E) U17, F) U19)*; team length* (with G) U16, H) U17, I) U19) and *team width* (with J) U16, K) U17, L) U19) in offensive (black line) and defensive (grey line) phases.

3. 2. Sample entropy analysis

The results of *SampEn* analysis concerning offensive phase of the SSG have shown the lower values for the compound positional variables of U17 and U19 teams (see **Table 3**). These findings suggest that elder and more experienced groups of players have demonstrated more regular team' movement behavior.

Table 2. Results of sample entropy analysis regarding the compound positional variables of offensive phase according to age/expertise level

Compound positional variables	Attack		
	U16	**U17**	**U19**
	x ± s (SampEn)	*x ± s (SampEn)*	*x ± s (SampEn)*
surface area	**0,085 ± 0,004***	0,083 ± 0,017	**0,076 ± 0,004***
stretch index	0,101 ± 0,029	0,082 ± 0,022	0,075 ± 0,029
team length	0,048 ± 0,006	0,043 ± 0,01	0,047 ± 0,009
team width	**0,086 ± 0,003*#**	**0,078 ± 0,005#+**	**0,07 ± 0,007*+**

* Significant difference between U16 and U19 $p < 0{,}001$;
# Significant difference between U16 and U17 $p \leq 0{,}001$;
+ Significant difference between U17 and U19 $p < 0{,}001$.

Table 3. Results of sample entropy analysis regarding the compound positional variables of defensive phase according to age/expertise level

Compound positional variables	Defense		
	U16	**U17**	**U19**
	x ± s (SampEn)	*x ± s (SampEn)*	*x ± s (SampEn)*
surface area	0,071 ± 0,008	0,072 ± 0,006	0,072 ± 0,01
stretch index	0,112 ± 0,031	0,118 ± 0,026	0,104 ± 0,027
team length	**0,042 ± 0,003#+**	**0,032 ± 0,003#***	**0,036 ± 0,003*+**
team width	**0,09 ± 0,003##**	**0,08 ± 0,008##**	0,084 ± 0,01

Significant difference between U16 and U17 $p \leq 0{,}001$;
Significant difference between U16 and U17 $p < 0.01$;
*Significant difference between U17 and U19 $p < 0{,}01$;
+ Significant difference between U16 and U19 $p < 0{,}01$.

Two-way mixed-model ANOVA analysis revealed a medium significant age/expertise effect ($p < 0{,}001$; $\eta^2 = 0{,}134$) on the regularity of the offensive *surface area* variation during the game, only when U16 (0,085 ± 0,004) and U19 (0,076 ± 0,004) groups were compared (see **Table 3** and **Figure 3A**). No significant differences in the regularity of offensive *surface area* variation during the game were registered between U16 and U17 teams, as well as between U17 and U19 teams. The significant age/expertise effect was observed on the regularity of offensive *team width* variation between all age groups ($p < 0{,}001$; $\eta^2 = 0{,}719$), when U16 and U17, U16 and U19, as well as U17 and U19 groups were compared (see **Table 3** and **Figure 3G**). No significant age/expertise effect on the regularity of variation over time of the offensive *stretch index and team length* has been observed.

The statistical analysis of the compound positional variables regarding the defensive phase revealed the significant age/expertise effect on the regularity of the *team length* variation during the SSG. The significant differences have been observed between all age groups ($p<0{,}001$; $\eta^2 = 0{,}573$), when U16 and U17, U16 and U19 and U17 and U19 groups were compared (see **Table 4** and **Figure 3F**). A significant age/expertise effect on the regularity of the defensive *team width* variation ($p<0{,}001$; $\eta^2 = 0.235$), have been observed only when U16 and U17 groups were

compared (see **Table 4** and **Figure 3H**). The results demonstrated no significant differences in the regularity of the defensive *team width* variation between U16 and U19, as well as between U17 and U19. No significant age/expertise effect on the regularity of variation of the defensive *stretch index* and *surface area* has been observed.

The data relating to the distribution of *SampEn* can be seen in **Figure 3**.

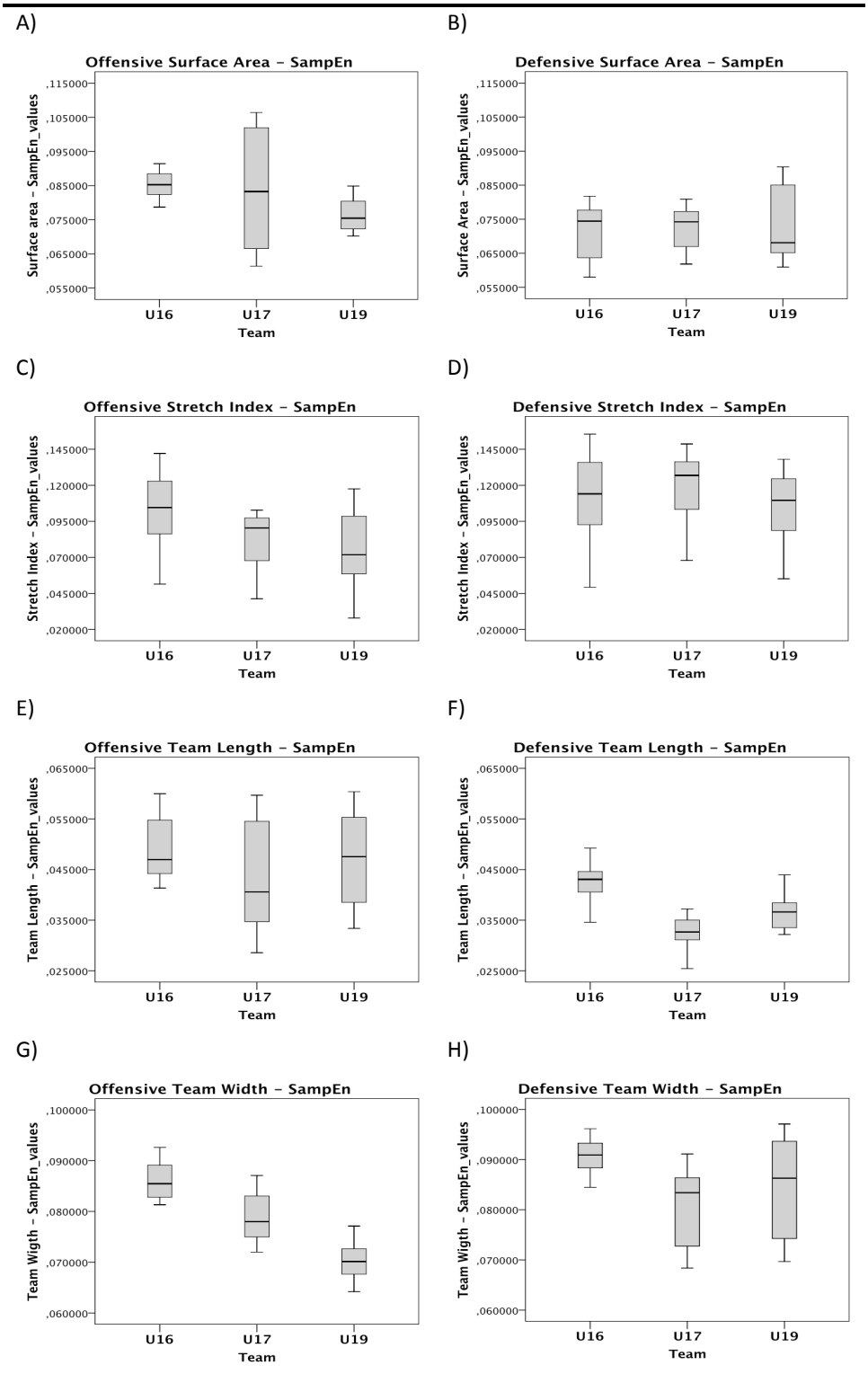

Figure 3. Distribution of the sample entropy values for the four compound positional variables of each age group on offensive and defensive phases of the game. A) offensive *surface area*; B) defensive *surface area*; C) offensive *stretch index*; D) defensive *stretch index*; E) offensive *team length*; F) defensive *team length*; G) offensive *team width* and H) defensive *team width*.

4. DISCUSSION

The main goal of this study was to analyse how the offensive and defensive collective behaviours performed in six-a-side game (GK+5 v. 5+GK) vary according to the age and expertise level of young football players (Under 16, Under 17 and Under 19). For this purpose, four measures of collective performance (*surface area, stretch index, length and width of a team*) have been analysed.

The SampEn analysis was used to assess the regularity of the collective behaviours during the defensive and offensive game phases. The results confirmed a significant age/expertise effect on the regularity of the teams' movement behaviour. The regularity of variation of *surface area* and *team width* in offensive phase and *team length* and *width* in defensive phase was significantly different in the observed age groups of players. In general the elder and more experienced players demonstrated more regular collective behavior. These results suggest that players of different age groups respond differently to the same SSG conditions, displaying different tactical behaviours. We suppose that elder and the more experienced teams demonstrate better team's tactical organization, particularly, in exploring game space. This finding is in line with the results of Sampaio and Maçãs, (2012), who analysed the collective behaviour in a five-a-side game before and after 13-week training and concluded that an increase of players' expertise is accompanied by more regular behaviour. Folgado and co-authors (2012) also verified that in younger football teams the dispersion of players on the pitch was characterized by a greater length and smaller width. It may suggest that younger players try to approach the goal quickly by solving the game tasks individually with the intent to be closer to the ball, instead of employing a collective approach and focusing on team play (Folgado, Lemmink, Frencken and Sampaio, 2012). In general, there is a broad consensus in literature concerned with collective behaviour in football, that players, choosing their displacements trajectories, are more focused on moving forwards and backwards along the pitch than moving across the pitch width (Frencken, Lemmink, Delleman and Visscher, 2011; Duarte, Araújo, Freire, Folgado, Fernandes and Davids, 2012; Folgado, Lemmink, Frencken and Sampaio, 2012; Sampaio and Maçãs, 2012). In fact, the ability to use pitch width seems to be related to players' expertize (Sampaio and Maçãs, 2012).

The analysis of regularity of players' behaviour in attack and defence revealed differences between these two processes. The time series of compound positional variables *stretch index* and *team width* showed more regular pattern in attack and time series of *surface area* and *team length* were more regular in defence.

When observing the values of the compound positional variables, the *surface area* measures, *stretch index* and *team width* were higher during the offensive phases of game in comparison to the defensive phases, at least for groups U16 and U17. The group U17 also demonstrated higher values in offensive *team length*.

These findings could be explained by particularities of offensive and defensive tactical behaviour. During the team attack the players' distribution in the lateral direction of the field (*team width*) tends to be higher, the attacking players try to explore all the amplitude of the pitch, while the average distance between players and the centre of the team (*stretch index*) and occupied area per players (*surface area*) is also increasing. In defensive phase the players try to protect the central zone of the pitch at the first place, so the *team width* and *surface area* tend to be smaller.

The Pearson correlation coefficients have pointed out a significant negative relationship between offensive and defensive phases for all the measures of collective behaviour for all age groups, with the exception to *team length* of U16 group.

A strong relationship between attack and defence *surface area* measures is not in line with the results of Frencken and Lemmink (2008), Frencken, Lemmink, Delleman and Visscher, 2011, and Duarte et al. (2012). The researchers verified the relationship between the areas occupied by the players in attack and defence. Duarte at al. (2012), suggest that this feature of collective performance could indicate that there is no predominant inter-team coordination pattern for the

surface area. The authors observed that in three-a-side game teams increase or decrease their *surface area* independently of the behaviours of the opposing team. Their data also demonstrated that the *surface area* had limited capacity to capture the coordination dynamics between these two teams near the scoring zone, and confirmed what was observed by Frencken and Lemmink (2008) and Frencken, Lemmink, Delleman and Visscher, (2011) concerning with this variable. Frencken and co-authors also revealed no linear association for the surface areas of the teams and they suppose that this is due to the type of SSGs used in their study. It was hypothesized that variations of *surface area* of each team were the result of coordination tendencies emerged within each team and were constrained by the functional relations between their own players during the approach to the scoring zone. Thus, the relationship between offensive and defensive compound positional variables was justified by SSG format and by particular events, which occurred during the game (Passos et al., 2006; Frencken, Lemmink, Delleman and Visscher, 2011; Duarte, Araújo, Freire, Folgado, Fernandes and Davids, 2012). In our study the trajectories of time series that characterized the attacking team's movement of U19 group crossed the ones of the defending team. The crossover was also observed between offensive and defensive trajectories of *surface area* e *team length* of U16 group. It seems that the relationship between the attack and defence players' movements established by elder and more experienced players is different from the younger players. U19 group demonstrated a smaller gap between the offensive and defensive positional variables in comparison to younger groups of players (see **Figure 3**). According to Frencken et al., (2011) "crossover" could be characterized as a prerequisite for scoring a goal. To better understand the reason for the crossover of offensive and defensive trajectories of positional variables further analysis of players' actions with and without the ball is needed.

Pearson correlation analysis revealed that the variables with highest relationship between attack and defence were *surface area* and *stretch index*. According to Duarte et al. (2012) the *surface area* and *stretch index* shared a similar nature and both measures showed similar patterns observed at the 11-a-side game level of analysis. As far as *surface area* and *stretch index* describe the players' dispersion on the field, our findings confirmed that players' dispersion in attack and defence are strongly but negatively correlated. It seems that defenders react to the increasing of attackers' dispersion by reducing of the inter-players space, especially on the central zone of the field to protect the goal.

According to Fradua et al. (2013), it is possible to design SSGs with a more valid representation of the tactical conditions, which are appropriate to full-size matches. In this case the use of SSG may contribute to improving of the training effect on tactical aspects of performance in football. In this way, SSGs context may be identified as sub-stages of the full size game, but their own characteristics (field size, number of players, length-width ratio, use or not of goalkeepers and rules / objectives of the game) have to be taken into account.

The results of our study contribute to better understanding of the effect of age and expertise on how the young football players manage the functional space in offensive and defensive phases of six-a-side football game.

5. CONCLUSIONS

Our findings demonstrated that the age and expertise level of players influence their collective behaviour in SSGs.

The results confirmed a significant age/expertise effect on the regularity of the teams' movement behaviour. The regularity of variation of *surface area* and *team width* in offensive phase and *team length* and *width* in defensive phase was significantly different in the observed age groups of players.

The elder and more experienced groups revealed more regular team's behaviour in comparison to younger players.

The variables that characterized the players' dispersion (*surface area* and *stretch index*) have shown the strongest negative correlation in attack and defence.

The methodology and results of this study supported further research related to collective behaviour in SSG with the purpose to increase the knowledge about the football game and offer the coach effective practical tools to better guide the daily training process. Despite the large application and unquestionable utility of SSG in football training, it is necessary to continue the research of players behaviour in this kind of drills, using SSGs with more players of different expertise levels (professional and amateur). Further researches are needed to evaluate the potential generalization of our findings and better understand whether the compound positional variables can be considered as reliable performance indicators in the monitoring of learning and performance during long-term soccer talent developmental programs.

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