Age-related effects of practice experience on collective behaviours of football players in small-sided games

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AGE-RELATED EFFECTS OF PRACTICE EXPERIENCE ON COLLECTIVE BEHAVIOURS OF SOCCER PLAYERS IN SMALL-SIDED GAMES

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Abstract

The purpose of this study was to examine whether offensive and defensive collective behaviours performed in six-a-side football games (GK+5 vs. 5+GK) varied according to age- related practice experience of young players (U16, U17 and U19 yrs). The players' movement trajectories (2D analyses) were recorded using 10 GPS units. Four common measures of team dispersion (*surface area*, *stretch index*, *length* and *width* of a team) were used to analyse team performance behaviours. After calculating these collective variables, we used approximate entropy (ApEn) and cross-approximate entropy (Cross-ApEn) measures to assess the regularity and synchronization of participant actions in the teams. Results demonstrated clear age-related variations in effects on the performance measures analysed. In attacking phases, older and more experienced players occupied a greater *surface area* and revealed greater regularity. In defensive phases, significant differences were observed only in *team length*, as well as in regularity of variation of *surface area* between older age groups (U17 and U19 yrs). The Cross-ApEn analysis demonstrated a greater synchronization between offensive and defensive *surface areas* in the U17 yrs old group. Data suggest how coaches can manipulate practice constraints to enhance development of tactical performance behaviours in footballers between 16 to 19 yrs of age.

Keywords: *small-sided games, compound positional variables, age- related experience, entropy analysis, soccer.*

1. Introduction

The use of small-sided games and conditioned (SSGs) is a common approach in training of association football players of different ages and skill levels (see Hill-Haas, Coutts, Rowsell & Dawson, 2008; Duarte et al., 2010; Hill-Haas, Dawson, Impellizzeri & Coutts 2011). These popular training practice tasks offer many advantages in acquiring relevant skills and can provide physiological and tactical adaptations in players leading to performance development (Hill-Haas et al., 2011; Frencken, Lemmink, Delleman & Visscher, 2011; Sampaio, Lago, Gonçalves, Maçãs & Leite, 2013). The majority of studies conducted in this field of research has tended to focus on physiological outcomes of SSG performance (e.g., Owen, Twist & Ford, 2004; Rampinini et al., 2007), especially physical and motor responses (e.g., Hill-Haas et al., 2009; Casamichana & Castellano, 2010), as well as on technical and tactical performances of players (e.g., Hill-Haas et al., 2009; Dellal et al, 2011). In recent years, the study of team tactical behaviours in SSGs has been based on the dynamical information about player interactions and on-field emergent coordination tendencies (Frencken et al., 2011; Folgado et al., 2012; Sampaio & Maçãs, 2012; Sampaio et al., 2013). According to Hughes and Bartlett (2002), tactical performance indicators in team invasion games, such as soccer, seek to reflect the relative importance of teamwork, pace, fitness and movement on field. Player behaviours on field display a high degree of variability, being dependent on continuous interactions between teammates, opponents and ball possession (Davids, Araújo, & Shuttleworth, 2005; Folgado et al., 2012), which makes it difficult to fully interpret outputs of notational or motion analysis procedures based on analysis of individual performance measures.

In seeking to analyse interactive behaviours of athletes during competitive performance, previous studies have investigated various team dispersion variables, such as: *surface area* (Frenchen et al., 2011; Duarte, Araújo, Freire, Folgado, Fernandes & Davids, 2012), *stretch index* (Bourbousson, Sévec & Mcgarry, 2010; Duarte, Araújo, Freire, Folgado, Fernandes & Davids 2012; Duarte, Araújo, Folgado, Esteves, Marques, & Davids, 2012), *team width and length* (Sampaio & Maçãs, 2012; Duarte et al., 2012; Fradua, Zubillaga, Caro, Fernandez-García, Ruiz-Ruiz & Tenga, 2013), *length per width ratio (lpwratio)* (Folgado, Lemmink, Frencken & Sampaio, 2012) and distances between *each team's centroids* (Folgado et al., 2012; Duarte et al., 2012; Sampaio & Maçãs, 2012; Sampaio et al., 2013). These interactive performance variables have been used to capture and synthesize, at a team level, the diversity of player movement

trajectories in relation to each other on field during competitive performance. In one exploratory study, Frencken and Lemmink (2008) analysed the collective behaviours of two competing football teams during five-a-side games (GK+4 vs. 4+GK), using *centroid* and *surface area* measures. They confirmed the usefulness of both variables for describing the ebb and flow of competitive games, players' interpersonal coordination tendencies, and the emergence of goal-scoring opportunities. Later, Frencken et al. (2011) identified a crossing of centroid positions in attacking teams, compared to those of defending teams in a forward-backward direction in 53% of the goals scored during SSGs. In similar vein, Duarte et al. (2012) examined the emergent patterns of coordination in four-a-side games (GK+3 vs. 3+GK) near the scoring zone. Also, using *centroid* and *surface area* measures, they reported how both teams moved forward and backward in a highly synchronized spatiotemporal manner. This observation reflected the coordinated activity of attackers and defenders near the goal area. Findings also emphasized that major transitions in collective behaviours of each team emerged just before an assisted pass was made (i.e., leading to a loss of stability in the state of a four-a-side game).

Sampaio and Maçãs (2012) used dynamical positional data of players to assess changes in the tactical behaviours using a pre and post-test design. After a 13-week constructivist and cognitivist training program, tactical behaviours were assessed during five-a-side performance. Regularity of tactical behaviours was analysed with approximate entropy (ApEn), a non-linear statistical method. ApEn values were lower in post-test situations, suggesting that player movement trajectories became more regular as a result of a training intervention. In a more recent study, Sampaio et al. (2013) compared time-motion variables, heart rate and players' tactical behaviours according to game pace (slow, normal and fast), match status (winning and losing) and quality of opposition (superior and inferior) in five-a-side soccer games. They experimentally verified how the dynamic positional data of player performances, analysed with non-linear tools, such as ApEn, might reveal their adaptive behaviours in dynamical performance environments.

Previous research has confirmed that, from a constraints-led perspective, SSG format (pitch size, number of players and rule modifications) has implications for the emergence of individual and collective actions performed by players (Duarte et al., 2010; Ford & Williams, 2012; Almeida, Ferreira & Volossovitch, 2013). Nevertheless, it remains to be clarified how players of different ages, differing in physical and psychological capacities as well as levels of

playing experience, perform under different practice task constraints. Are their performances similar, or does maturation and development, as well as greater learning and playing experience, shape the way that older and younger developing footballers coordinate their interpersonal interactions with other players over space and time? If not, how can observe differences be explained in terms of the adaptive behaviours of players? Which collective variables change between the key ages of 16 to 19 yrs in the investment period (Coté, Baker, & Abernethy, 2007), and which do not? This information is needed so that performance development programmes can be designed on the basis of empirical understanding of emergence of team tactical behaviours.

To the best of our knowledge, only a single study has analysed possible age-related differences in team dispersion behaviours in young footballers (Folgado et al., 2012). That study compared the performance of three different age groups (under-9, under-11 and under-13 yrs) in two SSG formats (GK+3 vs. 3+GK and GK+4 vs. 4+GK), studying the collective variables of *lpwratio* and *team centroid distance*. Data revealed that the distribution of younger players on field was characterized by a higher ratio of length per width, as well as by a reduced distance between the geometric centers of the teams. It is also worth noting that players of different ages responded in different ways to the changes in SSG format. However, there is an absence of empirical evidence about these aspects in players approaching the final stage of development, in the so-called investment years (Coté et al., 2007) (over 16 years of age). Since this phase of development is critical for a successful transition to a professional career in football, a detailed understanding of team behaviours evolving at these age levels could be fundamental to implement an evidence-based practice approach to the formatting of SSGs. For example, the data could provide some evidence on how the age-based maturation of players might shape their propensity to display team tactical behaviours in different SSG formats. This information would inform interpretation of performance evaluations in athlete development programmes in team sports.

The aim of the present study was to examine how team dispersion behaviours evolved across three different age groups (U16, U17 and U19 yrs) in the investment years, during attacking and defending phases of game play. More specifically, our approach sought to analyse potential age-related effects on the regularity and synchronization of team's behaviours (predicated on differences in maturation and development), as well as learning and competitive experience during six-a-side games.

2. Methodology

2. 1. Procedures

Data were collected from a convenience sample of thirty-six, male football players of three different age groups (U16, U17 and U19 yrs). Each group consisted of twelve players (ten players and two 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 evaluations were selected to participate in the study.

Each age group was divided into two balanced teams (one goalkeeper, two defenders, two midfielders and one forward) that participated in the six-a-side games. The game system, team composition and the playing positions of the participants were the same across all experimental sessions. Player positions were attributed according to the typical positions adopted by players in training and competition. The three groups of participants completed three independent sessions separated by one-week intervals. 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 was played for a duration of eight minutes on a 33m x 60m (width-length) pitch with an allocation of 165m^2 area per player that meets the football field proportions.

****Table 1 near here****

Official rules of association football were implemented in the games, with the exception of the offside rule. Also, goalkeepers were limited to two-touch play with their feet. The movement displacement trajectories (2D) of players were registered using ten units of a Global Positioning System (GPS) – (SPI PRO tracking system, GPSports, Canberra, Australia), held by a special vest, worn at the top of the players back. Positional data, speed and distance covered were recorded at 15Hz from each participant throughout each session. After each training session, positional data were collected using the software Team AMS R2 2010 that connected each of the GPS devices for downloading participant coordinate data. Each game resulted in 7000 data points for each player in the x- and y- component of motion. Validity and reliability of these instruments have already been provided by the manufacturers and have been subjected to

independent verification (e.g., Coutts & Duffield, 2010; and Gray, Jenkins, Andrews, Taaffe, & Glover, 2010).

The data recorded by the GPS were exported to MATLAB R2009b in order to convert the coordinate data of the players from degrees to meters (see procedures in Folgado et al., 2014) and calculate the compound variables that characterize the collective tactical behaviours. A total of 268 attacking and 268 defending episodes were selected from a total of nine SSGs performed by all participants in the groups. The following criteria were used in selecting the game episodes: 1) number of passes - 1 pass since that followed by carrying the ball with more than 3 ball touches; 2 passes since that followed by carrying the ball with more than 2 ball touches; or more than 2 passes; 2) carrying the ball - ball carrier made more than 4 ball touches; 3) the team was in ball possession more than 3 seconds (Reis et al., 2013). The episode was selected when at least one of the three criteria was met. Only the time-series with a minimum of 50 data points were included in the sample to ensure reliability of ApEn statistics (Stergiou, Buzzi, Kurz et al., 2004).

The experimental protocol was approved by the Ethics Committee of the Faculdade de Motricidade Humana – Universidade de Lisboa. Players and their parents were fully informed about the aims and procedures of the study and signed an informed consent form.

2. 2. Measures

Data from four compound positional variables were calculated for each team during the SSGs: *surface area*, *stretch index*, *team's length* and *width* (see **Figure 1**). As proposed in some recent studies (Lames, Erdmann & Walter, 2010; Duarte et al., 2012, Frias & Duarte, 2014), the collective performance measures were calculated only for five outfield players of each team, excluding the goalkeepers.

Surface area was calculated using a specifically designed Matlab function (convhull) that creates a convex polygonal area from a given number of points. For this purpose, we used a maximum number of 5 points corresponding to the 5 outfield players of each team. The function returns the selected points that compose the polygon and the polygonal surface area for each time frame (e.g., Duarte et al., 2012). This variable expresses the relationship between the tactical

forms (shapes) adopted and spaces exploited by both teams, to support analysis of how they varied over time.

Stretch index measures the radial expansion or contraction that a team demonstrated as the game unfolded (Bourbousson et al., 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 of the group of players (e.g., Yue, Broich, Seifriz & Mester, 2008).

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 (e.g., Duarte et al., 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 (e.g., Duarte et al., 2012). All computations were developed using routines implemented in MATLAB R2009b software (The MathWorks Inc, USA).

****Figure 1 near here****

2. 3. Data analysis

Descriptive statistics, such as mean (M) and standard deviation (SD), were used to analyse the magnitude of data variations in the three age groups. The ApEn measure was used to assess the complexity and regularity of specific team behaviours during the defensive and offensive game phases. ApEn is a non-linear statistical tool, which provides a measure of system complexity by quantifying the regularity (i.e., periodicity) and the structure of variability (i.e., the regularity with which specific patterns of variation occur) in a time-series. The computation of ApEn is based on the construction and comparison of patterns of length m. Given N data points $\{u(i)\}$ with $i = 1,...,N$, the algorithm constructs sequences $x_m(i)$ obtained by taking $x_m(i) = [u(i), ..., u(i + m - 1)]$, and it computes, for each $i \leq N - m + 1$, the quantity:

$$C_i^m(r) = N^{-1} \{\text{number of } x_m(j) \text{ such that } d[x_m(i),x_m(j) \leq r]\} \quad (1)$$

Where d [$x_m(i)$, $x_m(j)$] is the distance between the vectors, defined as max {|x(i)−x(j)|, ..., |x(i+ m−1)−x(j +m−1)|}.

$C_i^m(r)$ measures, with a tolerance r, the regularity of patterns by comparing them with a given pattern length m (m and r are fixed values: m is the length of the vector to be compared, r is a threshold or tolerance factor, which filters out irregularities). Thereafter, $\Phi^m(r)$ is defined as the average value of ln $C_i^m(r)$, where ln is the natural logarithm. The estimator of this parameter for an experimental time series of fixed length N is given by:

$$ApEn(m, r, N) = [\Phi^m(r) - \Phi^{m+1}(r)] \quad (2)$$

As extensively suggested in analyses of biological signals and movement data, in the current study, the m and r input parameters were set at 2 and 0.2 standard deviations, respectively.

Cross-approximate entropy (Cross-ApEn) was used to measure the asynchrony (conditional irregularity) of the variations of the different team dispersion variables during the offensive phase of team performance and the related defensive phase of the opposing team.

Cross-ApEn is an improved method of approximate entropy that allows an analysis of data from two time series, defining their relationship, and calculating the complexity within that relationship (Pincus & Singer, 1995; Richman & Moorman, 2000; Wu, Lee, Liu, & Liu, 2013). Cross-ApEn measures evaluate the similarities between the dynamical changes registered in two series.

The precise definition of Cross-SampEn is thematically similar to that for ApEn:

Let $u = (u(1), u(2), \ldots u(N))$ and v $(v(1), v(2), \ldots v(N))$ be two length-N sequences. Fix input parameters m and r. Form vector sequences x (i) $(u(i), u(I + 1), \ldots u(i + m - 1))$ and y $(j) = (v(j), v(j + 1), \ldots v(j + m - 1))$from u and v, respectively. For each $i \leq N + m - 1$, set $C^m_i(r)(v \| u)$ = (number of $j \leq N - m + 1$ such that d $[x(i), y(j)]$ $r) \leq (N - m + 1)$, where $d[x(i), y(j)] = \max_k = 1, 2, \ldots, m$ $(|u(i + k - 1) - v(j + k - 1)|)$, i.e., the maximum difference in their respective scalar components. The $C^m_i(r)$s measure, *within a tolerance r*, the regularity, or frequency of (v-)

patterns similar to a given (u-) pattern *of window length* m. Then, define $\Phi^m(r)$ ($v \parallel u$) as the average value of ln $C_i^m(r)$ ($v \parallel u$), and finally, define cross-ApEn (m, r, N) ($v \parallel u$) = $\Phi^m(r)$ ($v \parallel u$) = $\Phi^{m+1}(r)$ ($v \parallel u$).

For this study, we applied Cross-ApEn with m = 1 and r = 0.2 to offensive (= u) and defensive (= v) time-series data, i.e., for each participant. We applied Cross-ApEn (1, 0.2) to the $\{u^*(i), v^*(i)\}$ series, where $u^*(i)$ = (u (i) - mean u) / SD u and $v^*(i)$ = (v (i) - mean v) / SD v. This standardization, in conjunction with the choice of m and r, ensures good reliability properties for Cross-ApEn for the data lengths studied.

One-way ANOVAs were used to compare the values of the team dispersion variables across the three groups of players. The changes in regularity and synchronization of the four team dispersion variables according to age level (between-participants factor) in offensive and defensive game phases (within-participants factor) were tested using two-way mixed-model ANOVAs. When significant effects were found, Games-Howell post-hoc comparisons were applied. The effect sizes were reported as eta partial square (η^2) and interpreted as follows: small – 0.02, medium – 0.13 and large – 0.26.

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

The results of one–way ANOVA revealed how a key dependent variable was influenced by age-related effects: offensive *surface area.* Statistical analyses revealed a significant age-related effect with a small effect size ($P \leq 0.05$; $\eta^2 = 0.023$) for this variable. As can be seen from the data in **Table 2**, differences in *surface area* were observed between the U16 (176.6 ± 57.8) and U19 yrs (202.6 ± 68.5) participants. For other offensive variables *team width, team length* and *stretch index,* statistical comparisons of the differences between the teams were not significant. In defensive phases, a statistically significant difference ($P \leq 0.05$; $\eta^2 = 0.021$) was observed for *team length* between U17 (18.9 ± 5.2) and U19 yrs (20.9 ± 6.1) teams. As shown in **Table 3**, older players displayed higher average *team length* values. As expected, all age groups displayed higher values in *surface area*, *stretch index* and *team width* in the attack phases, compared to values observed in the defensive phases (**Tables 2 and 3**).

Significant differences between the U16 yrs and other participants (U17 and U19 yrs) were observed for ApEn values of *team width, surface area* and *stretch index* variables. These findings suggest that, in general, older and more experienced players tended to display more regular variations in space occupation during the offensive phase (see **Table 2**). No significant differences between the participant groups were observed for ApEn values in the attacking *team length*. Concerning the regularity of team behaviours during the defensive phases, the ApEn values for *team length* significantly decreased between the U16 and U17 yrs participant age groups ($P \leq 0.01$; $\eta^2 = 0.636$, see **Table 3**). Significant differences between the U16 yrs participants and those in other groups during the defensive phases were also observed for the ApEn value of *surface area* ($P \leq 0.05$; $\eta^2 = 0.695$, see **Table 3**). Once more, the older players demonstrated more regular behaviours.

****Table 2 near here****

****Table 3 near here****

The Cross-ApEn analysis revealed significant differences in the offensive *surface area* value between U16 (0.010 ± 0.016) and U17 yrs (0.006 ± 0.007) groups (see Table 4.), revealing a small age effect ($P \leq 0.05$; $\eta^2 = 0.229$).

****Table 4 near here****

4. Discussion

The data from this study revealed how participant age and practice experience influenced their interpersonal interactions and use of functional space available, on field during performance in six-a-side games. Results suggested that, when attacking, older and more experienced players occupied a greater area on field and displayed more stable (less variable) collective behaviours during performance. These outcomes were likely based on their greater maturation and development and experience levels, compared to younger players.

For the variables, *team width, team length* and *stretch index*, statistical comparisons of the differences between the age groups were not significant. These results are not in line with data reported previously by Folgado et al. (2012). They showed how, the dispersion on field of younger and less experienced soccer players, were characterized by greater *length* and smaller *width* values compared to the older players. The findings of Folgado et al. (2012) imply that younger players (with less maturity and experience) may seek to approach the goal quickly, typically by dribbling towards goal with the ball individually or by using a less elaborate (immature) and direct playing style. This assumption is predicated on their obvious intent to swarm around the ball, instead of employing team-based tactics such as making short passes and providing supporting movements. Comparing the results of the present study and the data reported by Folgado et al. (2012) clearly reveal how age-related effects shape collective behaviours during SSGs in developing footballers. The variations in outcomes may be explained by the differences in participant ages, levels of practice experiences and g skill levels. While Folgado et al. (2012) analysed younger groups of players (U9, U11 and U13), in the present study we examined the performance behaviours of older players (U16, U17 and U19), hypothetically with less divergence of skill levels. Compared to the data of Folgado et al. (2012), our results indicated that older and more experienced players demonstrated a greater awareness and balance between the *team length* and *width*, which according to previous research reveals a more elaborate playing style (Button et al., 2013). In general, these results are aligned with a broad consensus emerging in the literature on collective behaviours in soccer, revealing that the players' ability to use a dominant direction of pitch space, when choosing their offensive displacements trajectories, seems to be related to their expertise levels (Button et al., 2013; Duarte et al., 2012; Folgado et al., 2012; Sampaio & Maçãs, 2012). Our findings may help coaches to distinguish different levels of inter-team coordination in players of different ages and, subsequently, may guide practitioners to more advanced understanding of how collective on field performance behaviours change, and do not change, during the investment years.

In the defensive phase significant differences were observed only in *team length* between the U17 and U19 yrs groups. Since the U16 group displayed similar values in defensive *team length* than the U19 group, the differences between the two older groups may not be attributed to age-related experience effects, but hypothetically to the particular defence tactics that teams routinely use. However, this is an issue for future research.

The ApEn analysis assessed the regularity of participant collective behaviours during defensive and offensive game phases. Results confirmed the significant age-related experience effects on the regularity of each team's collective movements. The regularity of variations of *surface area*, *team width and stretch index* measures in offensive phases, and in *team length* and *width and surface area* in defensive phases, differed significantly according to age group behaviours. In general the older and more experienced players demonstrated more regular team dispersion behaviours. These results suggested that players of different ages and practice experience did not respond similarly to the same SSG conditions, expressing different tactical behaviours, with a different time-evolving dynamics. We assume that older and more experienced teams demonstrated more functional tactical organization, particularly, in exploring and exploiting on field space. Thus, these findings are in line with data reported by Sampaio and Maçãs, (2012), who showed that increments in player expertise levels were accompanied by more regular behaviours. Our data suggest that changes in maturation and development and experience levels, with increasing age, also have the same effects on performance regularity.

Analysis of Cross-ApEn data indicated a significant difference in the process of attack-defence synchronization, but only as suggested in the values of *surface area* revealed by the U16 and U17 yrs age groups. This analysis showed again that variations in the values of offensive and defensive *surface areas* by older participants were more highly synchronized, compared to the younger group. Moreover, our results suggest that, in the six-a-side game format, defending players reduce the values of interpersonal distances with other performers, consequently re-shaping their covered area on field, in response to increases in the dispersion of attacking players.

A strong relationship observed between attack and defence *surface area* measures was not in line with results reported previously in the field (i.e. Frencken and Lemmink, 2008; Frencken et al., 2011; Duarte et al., 2012). Those researchers verified the small relationship between the areas occupied by players when in attack and defence. Duarte et al. (2012) also demonstrated that the *surface area* had limited capacity to capture the coordination dynamics between two teams near the scoring zone, confirming the results of Frencken and Lemmink (2008) and Frencken, et al. (2011) concerning with this variable. 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 team dispersion variables could be justified by SSG format and by particular events, which occurred during the game (Passos et al., 2006; Frencken et al., 2011; Duarte et al., 2012).

The results of our study contribute a better understanding of the effects of age and practice experience on how football players manage the functional space available in offensive and defensive phases of six-a-side football game formats.

5. Conclusions

Our findings suggested that the age-related experience of soccer players tend to influence their collective behaviours in offensive and defensive phases of SSGs. The likely mechanisms for these age-related differences are differences in maturation and development (e.g., physical and psychological capacities), as well as greater levels of experience and learning. A significant age effect on the regularity of the teams' movement has also been confirmed. The older and more experienced groups revealed more regular team behaviours in comparison to younger players. The higher synchronization between attack and defence space occupation has been also observed in older players.

The methodology and results of this study suggested the need for further research on collective behaviours in SSGs in order to increase knowledge about emergent collective behaviours in youth footballers. The data offer coaches effective practical tools to better guide training design in football development programmes. These data highlight how coaches and sports scientists can design SSG formats according to the capacities that are typically available to most players in different age groups. The findings reveal how conditioned games could be designed in order to enhance the interpersonal interactions needed in different phases of play according to available space on field. Further research is needed to evaluate the potential generalization of our findings and to better understand whether team dispersion 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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Table(s)

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*	Practice experience (years) *mean ± SD*	Total oficial games (number) *mean ± SD*	Trainning sessions p/ week (hours)
U 16	15.2 ± 0.4	1.74 ± 0.03	62.6 ± 4.2	20.7 ± 2.2	6 ± 1.76	150 ± 44.1	6 (4 x 1h30')
U 17	16.3 ± 0.5	1.78 ± 0.04	67.5 ± 4.05	21.3 ± 1.9	7 ± 1.4	175 ± 35.4	6 (4 x 1h30')
U 19	17.4 ± 0.5	1.80 ± 0.07	69 ± 5.8	21.1 ± 2.1	8.7 ± 2.8	217 ± 70.8	6 (4 x 1h30')

Table 2. Results of descriptive statistics and ApEn data for four compound positional variables (*surface area, stretch index, team's width and team's length*) collected in offensive phase, according to age groups (U16, U17 and U19).

	Attack							
	Team's Width		Team's Length		Surface Area		Stretch Index	
	D.Statistics mean ± sd	ApEn mean ± sd	D.Statistics mean ± sd	ApEn mean ± sd	D.Statistics mean ± sd	ApEn mean ± sd	D.Statistics mean ± sd	ApEn mean ± sd
U16	17,6 ± 4,6	0,016 ± 0,011*∞	20,2 ± 4,8	0,016 ± 0,012	176,6 ± 57,8$^{\#}$	0,023 ± 0,014°$^{\#}$	9,2 ± 1,45	0,012 ± 0,009°$^{+}$
U17	18,8 ± 4,6	0,012 ± 0,005∞	19,8 ± 5,3	0,014 ± 0,007	189,3 ± 74,2	0,018 ± 0,008°	9,4 ± 1,9	0,01 ± 0,004°
U19	19,2 ± 4,7	0,012 ± 0,007*	21,3 ± 5,6	0,013 ± 0,007	202,6 ± 68,5$^{\#}$	0,017 ± 0,009$^{\#}$	9,8 ± 1,8	0,01 ± 0,005^{+}

* Significant difference between U16 and U19, $p \leq 0{,}001$; ° Significant difference between U16 and U17, $p \leq 0{,}01$;

$^{+}$ Significant difference between U16 and U19, $p \leq 0{,}01$; ∞ Significant difference between U16 and U17, $p \leq 0{,}05$;

$^{\#}$ Significant difference between U16 and U19, $p \leq 0{,}05$.

Table 3. Results of descriptive statistics and ApEn data for four compound positional variables (*surface area, stretch index, team width and team length*) of defensive phase according to age groups (U16, U17 and U19).

	Defense							
	Team Width		Team Length		Surface Area		Stretch Index	
	D.Statistics	ApEn	D.Statistics	ApEn	D.Statistics	ApEn	D.Statistics	ApEn
	mean ± sd	mean ± sd	mean ± sd	mean ± sd	mean ± sd	mean ± sd	mean ± sd	mean ± sd
U16	16,5 ± 4,5	0,016 ± 0,011∞	20,3 ± 5,5	0,016 ± 0,014∞	172,5 ± 75,8	0,023 ± 0,015∞#	9,1 ± 2	0,013 ± 0,011
U17	17,7 ± 4,4	0,012 ± 0,008∞	18,9 ± 5,2•	0,012 ± 0,008∞	173,7 ± 71,6	0,018 ± 0,01∞	8,9 ± 1,8	0,01 ± 0,008
U19	17,3 ± 3,7	0,013 ± 0,011	20,9 ± 6,1•	0,014 ± 0,009	186,1 ± 68,6	0,018 ± 0,014#	9,3 ± 1,8	0,01 ± 0,008

∞ Significant difference between U16 and U17, $p \leq 0,05$; # Significant difference between U16 and U19, $p \leq 0,05$;

•Significant difference between U17 and U19, $p \leq 0,05$

Table 4. Results of Cross-ApEn analysis regarding the synchronization between compound offensive and defensive positional variables according to players' age.

	Attack vs. Defense			
	Team Width	Team Length	Surface Area	Stretch Index
	Cross-ApEn	Cross-ApEn	Cross-ApEn	Cross-ApEn
	mean ± sd	mean ± sd	mean ± sd	mean ± sd
U16	0,009 ± 0,014	0,009 ± 0,012	0,010 ± 0,016∞	0,008 ± 0,010
U17	0,005 ± 0,007	0,005 ± 0,006	0,006 ± 0,007∞	0,004 ± 0,004
U19	0,007 ± 0,015	0,009 ± 0,015	0,007 ± 0,014	0,005 ± 0,008

∞ Significant difference between U16 and U17 $p \leq 0,05$

Figure(s)

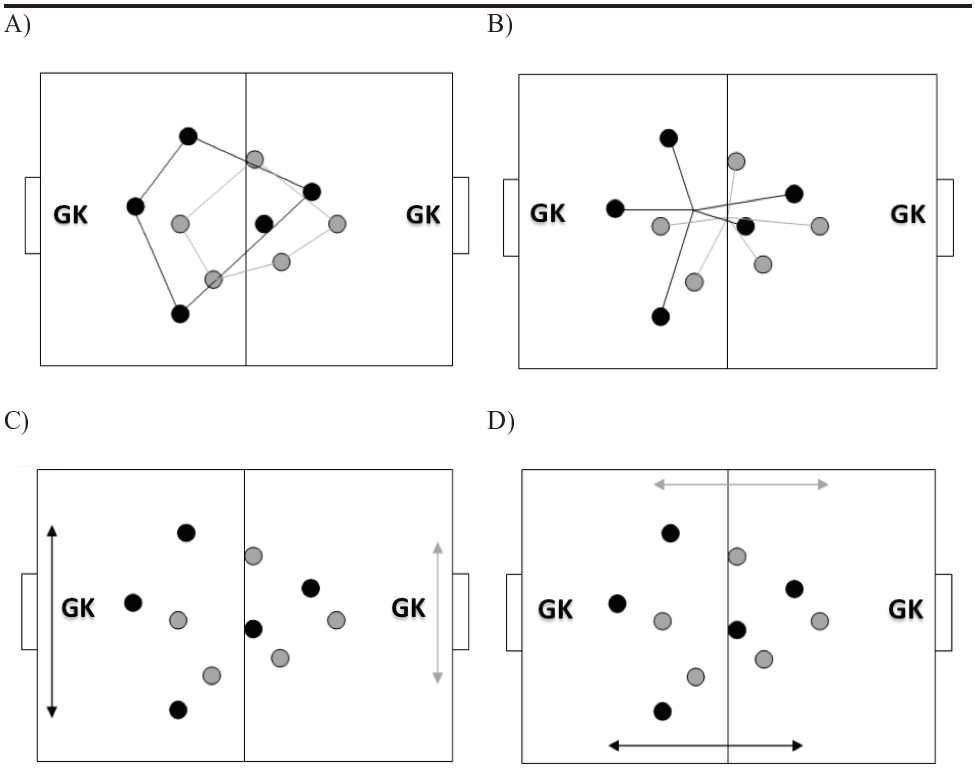

Figure 1. The illustration of the four compound positional variables: A) *surface area*; B) *stretch index*; C) *team's width*; D) *team's length;*