Effects of manipulations of player numbers vs. field dimensions on inter-individual coordination during small-sided games in youth football

SILVA, Pedro, ESTEVES, Pedro, CORREIA, Vanda, DAVIDS, Keith <http://orcid.org/0000-0003-1398-6123>, ARAÚJO, Duarte and GARGANTA, Julio

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Effects of manipulations of player numbers vs. field dimensions on inter-individual coordination during small-sided games in youth football

Pedro Silva[1], Pedro Esteves[2,3], Vanda Correia[4,5], Keith Davids[6,7], Duarte Araújo[5] & Júlio Garganta[1]

[1] CIFI²D – Centre for Research, Education, Innovation and Intervention in Sport, Faculdade de Desporto, Universidade do Porto, Porto, Portugal
[2] School of Education, Communication and Sport, Polytechnic Institute of Guarda, Guarda, Portugal
[3] CIDESD – Research Center in Sports, Health Sciences and Human Development, Portugal;
[4] School of Education and Communication, University of Algarve
[5] CIPER, Faculdade de Motricidade Humana, Universidade de Lisboa, Cruz Quebrada Dafundo, Portugal
[6] Centre for Sports Engineering Research, Sheffield Hallam University, UK
[7] FidiPro Programme, University of Jyväskylä, Finland

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Abstract

The relative space per player formulated in small-sided and conditioned games can be manipulated either by promoting variations in player numbers or by modifying field dimensions. In this study we analysed how the same relative space per players, obtained through manipulations of player numbers and field dimensions, influenced inter-individual coordination. It was used positional data (GPS, 10 Hz) of 24 U-15 yrs football players performing in three different relative spaces per players (118, 133 and 152m^2). Inter-individual behavioural measures included: (i) effective relative space per player, (ii) radius of free movement; (iii) ***numerical relations inside each player's relative space per player; and (iv) players' spatial distribution variability. Results sh*****owed that manipulations of player numbers elicited more free space in the vicinity of each player. However, more advantageous numerical relations adjacent to each individual player during performance were observed during manipulations of field dimensions. The latter also promoted broader player spatial distributions on field. These findings highlight the complex nature of performance behaviours in team sports captured by the co-adaptation of players to specific surrounding spatial constraints. Sport pedagogists can harness the coordination tendencies that emerge under specific constraints manipulations, but should carefully evaluate the use of player numbers and field dimensions as strategies to simulate constraints of specific game contexts.**

1. Introduction

Team ball sports like association football are considered complex systems where patterns of coordinated behaviour emerge under constraints of dynamically changing performance environments (Duarte et al., 2013; Passos et al., 2008). To understand coordination dynamics in social complex systems like team games it is mandatory to not just study the motion of each independent component (i.e. competing and cooperating players). Rather, coordination tendencies between team sports players emerge from spatiotemporal interactions between performers as they adapt to evolving performance constraints, such as opponents moving towards a scoring target (Duarte et al., 2012).

Recently, some studies have adopted a complex systems orientation to examine how manipulations of specific constraints in small-sided and conditioned games[1] (SSCG) influence interpersonal behaviours of performers (for a review see (Davids et al., 2013)). This recognition that SSCG provide a viable opportunity to develop individual and collective performance behaviours, requires more effort to capture the tactical coordination processes that emerge from interpersonal interactions of players and/or groups of players during performance in such practice tasks. Developing understanding in this area of work is crucial for designing effective practice simulations in team sports since the co-adaptations of individual players reflect the tactical behaviours that occur under specific task constraints.

Within the context of SSCG, the relative space per player (relative space per player, or individual playing area) – here considered as the total available field area divided by the number of players (Casamichana and Castellano, 2010) - might impact on performance behaviours (Fradua et al., 2013; Platt et al., 2001). Either by manipulating field dimensions or player numbers, changes in relative spaces per player demand continuous adaptations in co-positioning and co-orientation between attackers and defenders (Chow et al., 2006; Davids et al., 2013).

Recently, Fradua et al. (2013) attempted to determine optimal relative spaces per player for different formats of SSCG, in view of the lack of solid evidence from studies in the field. The authors calculated the individual relative space per player by dividing the effective playing space (defined by the smallest rectangle encompassing all outfield players during competitive performance) by the twenty outfield players. With this information the investigators created SSCG field dimensions that closely replicated this relative space per player in an attempt to recreate the same spatial-temporal interactions of football matches.

The rationale for continuous spatial adaptations between players is predicated on the use of evolving informational sources, related to their relative orientation to the ball,

[1] Small-sided and conditioned games are commonly considered as modified games played on reduced pitch dimensions (small-sided), often using adapted rules and involving a smaller number of players than traditional games (representing manipulations of playing conditions) (Gabbett *et al.*, 2009; Vilar *et al.*, 2014). In team sports, they are considered to provide simulations of aspects of competitive performance environments which allow athletes to practice movement patterns and interactive tactical behaviours related to game phases like attacking and defending (Davids, et al., 2013).

scoring target, teammates and opponents, to regulate their performance behaviours (Silva et al., 2013). These intertwined relations invite actions (Withagen et al., 2012). As such they provide possibilities for acting in the game that sustain team coordination under the constraints of competitive performance environments (Silva et al., 2014e). For instance, decreases in relative space per player constrain the spatial-temporal interactions established between competing players due to reduced time and space to act. Hence, the numerical relations between players in the vicinity of each individual's location on field might also be constrained by the size of the relative space per player. Reduced available space may inevitably decrease values of interpersonal distance and faciliate the creation of different relations between the number of opponents and number of teammates near the players' action zones (e.g., overloading). Such numerical relations are an important aspect that must be considered, given that they may change tactical performance during SSCG (see Bruno Travassos et al. (2014) and Silva et al. (2014e)). During regular competitive performance, changes in numerical dominance of a team (i.e., through overloading in specific sub-areas of play) has been revealed as crucial in the maintenance of defensive stability and the creation of offensive opportunities (Vilar et al., 2013).

Previous studies analysing the effects of field dimensions on tactical behaviours have reported different co-adaptations between players as a function of different relative space per players created in experiments. Silva et al. (2014a) observed broader movement trajectories of players during performance, measured through the entropy of their spatial distributions on field under constraints of smaller values in SSCG. Vilar et al. (2014) demonstrated that fewer opportunities to maintain ball possession occurred within smaller field dimensions. In another study, Frencken et al. (2013) observed significantly different inter-team lateral and longitudinal distance values arising from different individual relative space per player on shorter performance area dimensions, resulting in smaller values of inter-team distances. To the best of our knowledge, it is unknown whether changes in relative space per player obtained through manipulating player numbers would provide the same interpersonal adaptations in performance behaviours as field dimensions manipulation.

The aim of this study was to extend knowledge on the functional utility of SSCG in understanding how specific manipulations of field dimensions and player numbers constrained youth football players' performance behaviours within the same relative space per player. We specifically investigated how field dimensions and player numbers manipulations, replicating the same relative space per player, affected individual playing areas, distance to nearest opponents and numerical relations emerging in SSCG using a team of under-15 yrs football players as participants. The regularity of the spatial distribution of players during performance was also analysed to verify how players reacted to more restricted or broader locations on field, by adapting to changes in surrounding information sources provided either by field dimensions and player numbers manipulations. Given that the existing literature on manipulations of relative space per player is sparse, we sought to evaluate insights from previous research, hypothesizing that the same values of relative space per player, promoted either by manipulations of player numbers or FD, would likewise constrain emergence of inter-individual performance-related behaviours.

2. Methods

2.1 Participants

Twenty-four players from an under-15 years football development squad (height: 165.63±7.62; body mass: 55.68±7.27) competing at a regional-level (playing and training experience: 6.11±2.05 years) participated in this experiment. Their legal tutors provided written informed consent authorizing their participation in this study after being informed of the benefits and risks of the experiment. All procedures were in accordance with the ethical standards of the ethics committee from the Faculty of Sports of Porto University.

2.2 Task and procedures

SSCG were designed to account for the same relative space per player, whether involving field dimensions or player numbers manipulations. Three relative spaces per player areas were considered for this experiment – 118, 133 and 152 m^2 (see Table 1). These areas have been calculated from a reference field dimension designed for a 6v6 game context – 57.3 x 37.1 m (length x width) that was obtained by reducing the width and length of an official football field – 105 x 68 m as a reference – in proportion to the number of players involved in a 6-a-side SSCG, as suggested in coaching literature (Hughes, 1994). The manipulation of players using a constant area of 57.3 x 37.1 m yielded 118, 133 and 152 m^2 relative space per player areas for 7v7, 8v8 and 9v9 game contexts, respectively. Then, the manipulation of field dimensions for a constant player numbers game context (i.e., 6v6) were calculated to match the same relative space per player areas of those from player numbers manipulations. Since different length per width relations of the fields could impact on the variables of this study (for instance, by promoting different shapes for the effective areas of play; see Silva et al. (2014c)), the same length per width ratio was maintained for all SCCGs. This ratio was the same of a regular football field (ratio: 1.54 – 105 x 68 m, as a reference).

Table 1 – Relative space per player (relative space per player) and small-sided games formats with manipulations of field dimensions and player numbers. The same ratio of length per width was maintained in all SSCG.

SSCG Constraints	Relative space per player - 152 m2	Relative space per player - 133 m2	Relative space per player - 118 m2
Field dimensions (Player numbers held constant)	6v6; 52.9 x 34.4 m (length x width)	6v6; 49.5 x 32.2 m (length x width)	6v6; 46.7 x 30.3 m (length x width)
Player numbers (Field dimensions held constant)	7v7 57.3 x 37.1 m (length x width)	8v8 57.3 x 37.1 m (length x width)	9v9 57.3 x 37.1 m (length x width)
Field Length x Width ratio	1.54	1.54	1.54

Given that the main objective was to analyse how players managed different relative spaces per player, the SSCG were played without goalkeepers to avoid the creation of spatial gaps between the former and the defensive line (Fradua et al., 2013). A natural attraction towards the central corridor promoted by the existence of goals was constrained by attributing points whenever a player crossed a scoring zone delimited with cones (separated by 8 m and centred on the opponent's team end line) with the ball under control (see Figure 1). All trials were conducted according to the official rules of association football, with the exception of the offside rule, which was not applied.

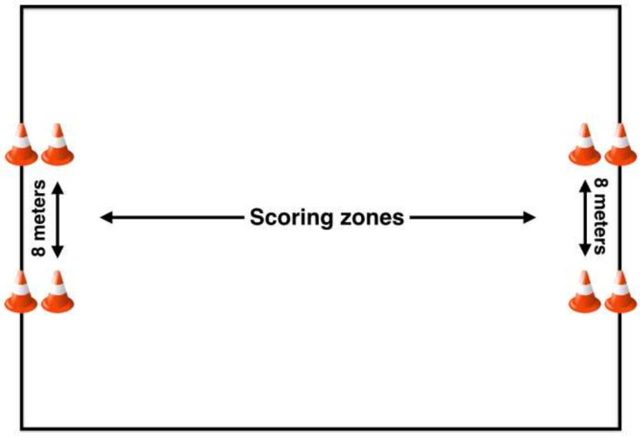

Figure 1 – Representation of the field and scoring zones.

In each treatment there were three matches of 6-mins duration, yielding a total of 18 games observed throughout a period of two weeks (6 days). All SSCG were conducted prior to the start of the team's regular practices and after an initial standard warm-up of fifteen minutes comprising drills with a ball (individually and/or in pairs) followed by sprinting activities and stretching. Matches were randomly distributed across training sessions and a period of 4-minutes between exercise bouts was allowed to facilitate passive recovery and rehydration. During rest periods, players were allowed to drink fluids ad libitum. The order of the SSGs was randomly set and only one trial per treatment was performed in each session, up to a maximum of three SSCG per session (see Table 2). Several balls were distributed around the experiment performance area in order to minimize trial stoppages. The players were instructed to not leave the performance area during the execution of the SSCG to maximise observation time by the experimenters. During the SSCG, neither the coaches nor the experimenters were allowed to provide instructions to players.

Table 2 – Distribution of the small-sided games across training sessions.

Week 1			**Week 2**		
Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**
6v6 (118 m^2)	6v6 (133 m^2)	9v9 (118m^2)	6v6 (152 m^2)	7v7 (152 m^2)	6v6 (118 m^2)
8v8 (133 m^2)	9v9 (118 m^2)	6v6 (133 m^2)	8v8 (133 m^2)	9v9 (118 m^2)	8v8 (133 m^2)

6v6 (152 m^2)	7v7 (152 m^2)	7v7 (152 m^2)	6v6 (118 m^2)	6v6 (133 m^2)	6v6 (152 m^2)

2.3 Data collection

Each player wore a global positioning tracking device (Qstarz, Model: BT-Q1000eX) that recorded his 2D positional coordinates at a sampling frequency rate of 10 Hz. The reliability of similar type of devices has been well documented in the literature (Coutts and Duffield, 2010; Johnston et al., 2013). The performance area was calibrated with the coordinates of four GPS devices stationed in each corner for approximately four minutes. The absolute coordinates of each corner were calculated as the median of the recorded time series, providing measurements that were robust to typical fluctuations of GPS signals. These absolute positions were used to set the Cartesian coordinate systems for each performance area, with the origin placed at the performance area centre. Longitudinal and latitudinal (spherical) coordinates were converted to Euclidean (planar) coordinates using the Haversine formula (Sinnott, 1984). Fluctuations in player positioning were reduced using a moving average filter with a time scale of 0.2 seconds. Data resampling was employed to synchronize the time series of all players within each trial.

2.4 Variables

Position data – longitudinal (x-) and latitudinal (y-) coordinates – obtained through the GPS system were used to calculate the: (i) effective relative space per player; (ii) radius of free movement; (iii) players' spatial distribution variability; and (iv), numerical relations established inside the individual relative space per player. The effective relative space per player was calculated according to the recommendations of Fradua et al. (2013). These authors proposed that the effective space allocated to each player should be calculated by dividing the area of the effective playing space delimited by the smallest rectangle encompassing all players, and not by dividing the total field area by the number of players. This quantity revealed the amount of free space, theoretically, that would be available for each player during each trial. In this study, however, for a more precise estimate of this variable, we calculated the polygonal area (m^2) defined by the players located at the periphery of play by computing the area of the smallest convex hull containing all players. For each SSCG this area was computed and divided by the number of players involved, second-by-second, yielding a total of 1083 measures per treatment (n = 6 minutes x 60 seconds x 3 trials per treatment).

The radius of free movement was defined as a measure of the degree of free movement without any opponents calculated in meters (m). For each player, the distance to his nearest opponent was quantified over time and averaged for statistical purposes. The spatial distribution variability was assessed by measuring the entropy (Shannon, 1948) of individual distribution maps. These were calculated by discretizing the SSCG fields into bins and measuring the amount of time spent in each bin according to the sampling frequency of 10 Hz for the GPS acquisition system. The spatial distribution maps were normalized to total trial time, to produce spatial probability distributions (heat maps). The size of the bins was the same for all performance areas, which were chosen to satisfy an adequate balance between high spatial resolution and high range of measured values. A bin size of 1 m^2 was used allowing both sufficient spatial detail and large variability in the bin counting (>100×dt). For visualization purposes only, the heat maps were spatially filtered with a Gaussian kernel with a standard deviation of 1 (bin). Considering a performance area partition with N bins and setting p_i as the measured probability of finding the player in bin i, the entropy S of the spatial distribution is

$$S = -\sum_{i=1}^{N} p_i \log p_i \quad (1)$$

Normalized entropy was used to place the results within the range between 0 and 1, allowing for comparisons between different field dimensions.

$$S\% = \frac{1}{\log N} \sum_{i=1}^{N} p_i \log p_i \quad (2)$$

High (near 1) and low (near 0) entropy values were interpreted as irregular and regular spatial distribution variability, respectively. A more irregular spatial distribution was interpreted as facilitating broader tactical involvement of players (e.g., advancing up field to attack and retreating back to defend, or playing both on the left and right sides of the performance area in the same SSCG). A more regular spatial distribution was considered to represent a more restricted tactical role (e.g., playing most of the time in a defensive role).

Finally, the numerical relations in the vicinity of each player were computed as the difference between the number of teammates and the number of opponents. To our knowledge there are no consistent guidelines for determining a player's momentary action zone for which his actions could be considered to directly influence and be influenced by the movements and numerical relations established between nearest opponents and teammates. Therefore, we calculated the circular relative space per player area surrounding each player, point-by-point over time that corresponded to each SSCG (118, 133 or 152 m^2), since, in theory, it is considered to represent the performance area allocated to each player (Casamichana and Castellano, 2010; Hill-Haas et al., 2011). For statistical purposes, the proportion of time spent in each of the numerical relations found was calculated for each player in each trial. The numerical relations "NR(+1)" (plus one teammate), "NR(=)" (equal number of teammates and opponents), "NR(-1)" (minus one teammate), "NR(-2)" (minus two teammates) and "NR(free)" (relative space per player free of players – teammates and/or opponents) accounted for at least 95% of the time in all SSCG. Other numerical relations were disregarded given that the number of occurrences was not reasonably large to be considered.

2.5 Data analysis

The effective relative space per player, radius of free movement, spatial distribution variability and numerical relations were analysed for practical significance using magnitude-based inferences (Buchheit and Mendez-Villanueva, 2014; Hopkins et al., 2009). Within- and between-treatment effect sizes with 90% confidence intervals were calculated using pooled standard deviations. Threshold values for Cohen's effect sizes were > 0.2 (small), > 0.6 (moderate), and > 1.2 (large) (Cohen, 1988). Probabilities were calculated to assess whether true effects obtained represented substantial changes (Batterham and Hopkins, 2005). The smallest standardised change for each variable was considered to be 0.2 multiplied by the between-subject standard deviation value, based on Cohen's effect size principle (Buchheit and Mendez-Villanueva, 2014). Quantitative probabilities of higher or lower differences were evaluated qualitatively as: < 1%, almost certainty not; 1-5% very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; > 99%, almost certain (Hopkins, 2002). If the probabilities of the effect being higher or lower than the smallest worthwhile difference were simultaneously > 5%, the effect was deemed unclear. Otherwise, the effect was clear and reported as the magnitude of the observed value.

3. Results

Figure 2 (upper left panel) shows standardised mean differences between manipulations of player numbers and field dimensions for the effective relative space per player, radius of free movement and spatial distribution variability. Descriptive statistics (mean ± standard deviation) of these quantities are summarized in Table 3. Differences can be observed for all variables and relative spaces per player treatments (118, 133 and 152 m^2). The effective relative space per player was larger for manipulations of player numbers with the largest difference being found in the smallest relative space per player (i.e., 118 m^2). The radius of free movement was also larger when relative space per player was set through manipulations of player numbers. A moderate difference was found in the smallest relative space per player (118 m^2), whereas for the 133 and 152 m^2 relative spaces per player the differences were minimal. Concerning the spatial distribution variability, a contrasting trend was found, with larger values of entropy being observed when the relative space per player was set through manipulations of FD. In this case, the magnitude of the differences was moderate to large, with the largest differences being found in the 118 and 133 m^2 relative space per player, and a moderate difference in the 152 m^2 relative space per player.

Figure 2 also shows differences within relative spaces per player treatments for the same variables. Manipulations of the relative spaces per player through player numbers had a minimal impact on the effective relative space per player. Differences between relative spaces per player were trivial (118 – 133 m^2 and 133 – 152 m^2) and small (118 – 152 m^2). On the other hand, when field dimensions was manipulated, the effective relative space per player varied more greatly, with moderate differences being found between the smallest relative space per player (118 m^2) and remaining relative spaces per player (133 and 152 m^2). Larger relative spaces per players elicited larger values of this quantity, except in the 133 – 152 m^2 comparison, where larger mean values were found on the 133 m^2 relative space per player, although with a small difference. The same trend was found for the players' radius of free movement, both for manipulations of player numbers and field dimensions, but with lower magnitude differences in the 118 – 152 and 118 – 133 m^2 pairwise comparisons.

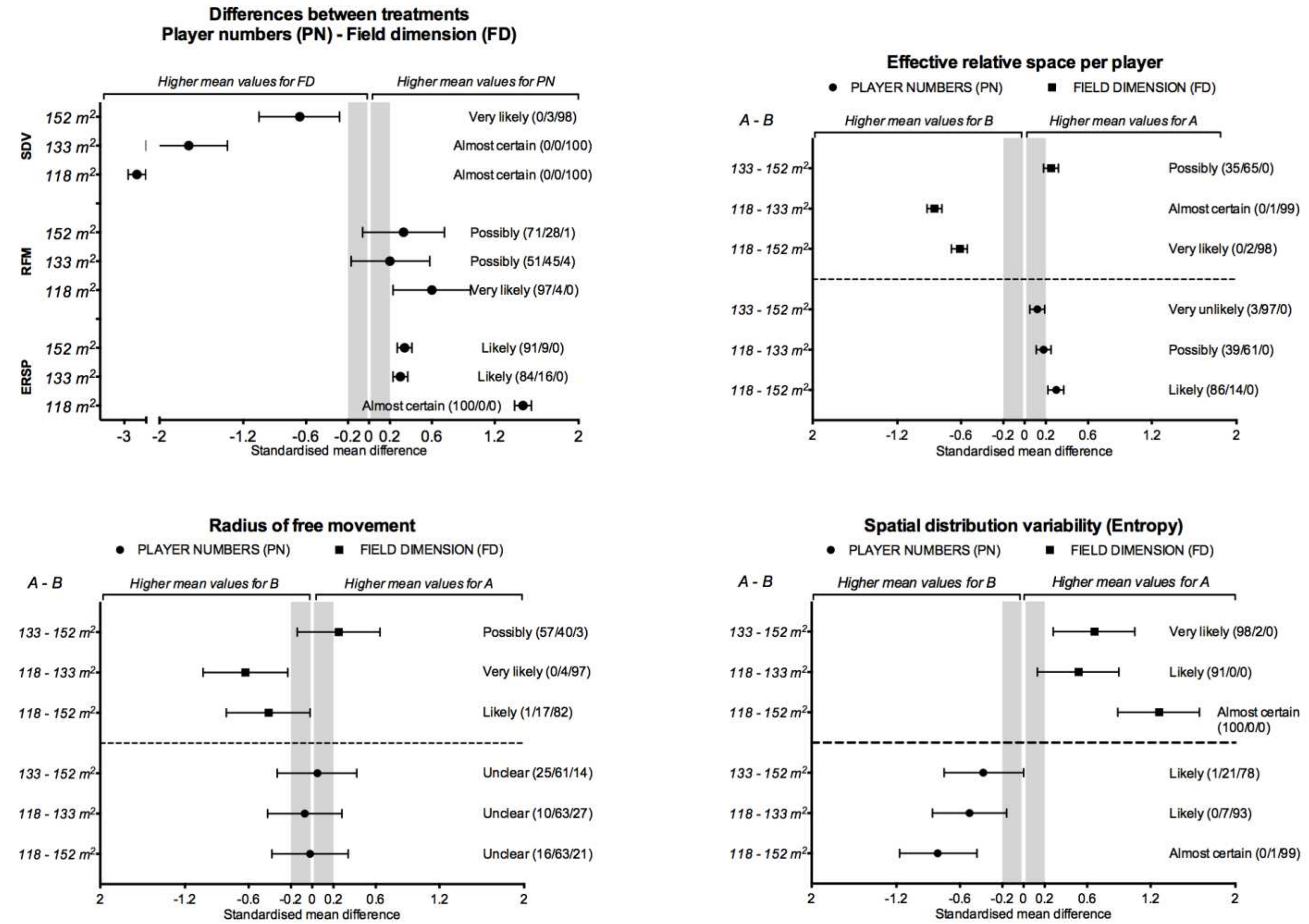

Figure 2 – Standardised mean differences between and within treatments (player numbers and field dimension) plus quantitative chances of higher or lower differences for (i) effective relative space per player, (ii) radius of free movement and (iii) spatial distribution variability. Error bars represent 90% confidence intervals and probabilities are reported as percentages of greater/similar/lower values. Shaded areas represent trivial differences.

Table 3 – Mean ± standard deviations of the effective relative space per player, radius of free movement and spatial distribution variability according to the relative space per player and constraints-type manipulation.

Relative space per player	**Manipulations on player numbers**			**Manipulations on field dimension**		
	Effective relative space per player (m^2)	Radius of free movement (m)	Spatial distribution variability (Entropy)	Effective relative space per player (m^2)	Radius of free movement (m)	Spatial distribution variability (Entropy)
118 m^2	33.86±6.61 n=1083	5.92±1.77 n=54	0.67±0.02 n=54	23.88±6.97 n=1083	5.02±0.98 n=36	0.72±0.01 n=36
133 m^2	32.6±7.1 n=1083	6.05±1.89 n=48	0.68±0.02 n=48	30.39±8.28 n=1083	5.72±1.21 n=36	0.71±0.02 n=0.36
152 m^2	31.71±7.86 n=1083	5.96±1.94 n=42	0.69±0.02 n=42	28.84±9.08 n=1083	5.44±1.03 n=36	0.7±0.02 n=36

With regards to values of participants' spatial distribution variability, Figure 2 (lower right panel) shows that manipulations of player numbers and field dimensions impacted differently on the players' movements on field. Lower relative spaces per player values, set through manipulations of player numbers, showed a tendency for lower values of entropy (small to moderate differences; Figure 3). However, tendencies for larger values of entropy were found for lower relative spaces per player when manipulations of field dimensions were undertaken (with a large difference found between 118 – 152 m^2). Figure 4 displays an example illustrated through exemplar heat maps of one player across all SSCG conditions.

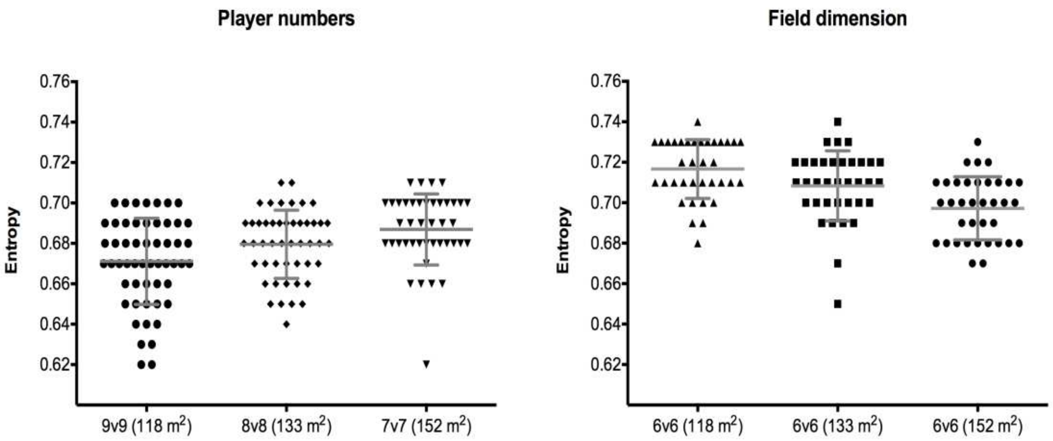

Figure 3 – Mean and distribution of entropy measures. Error bars represent standard deviation.

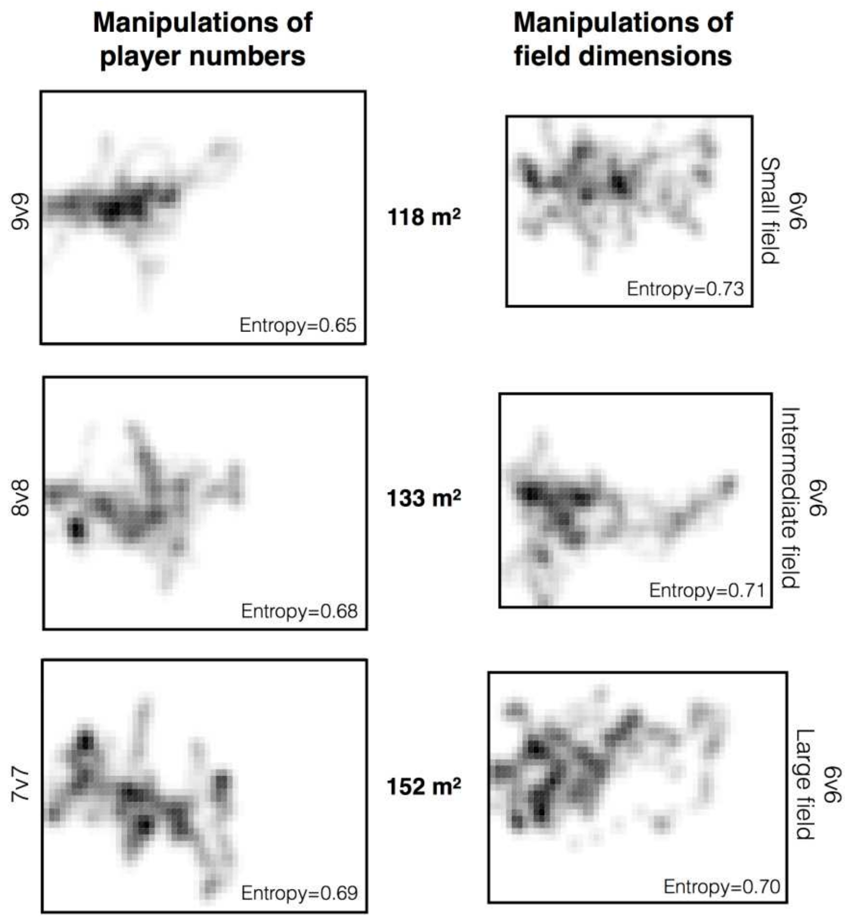

Figure 4 – Exemplar spatial distribution maps and entropy measures of one single player across SSCG.

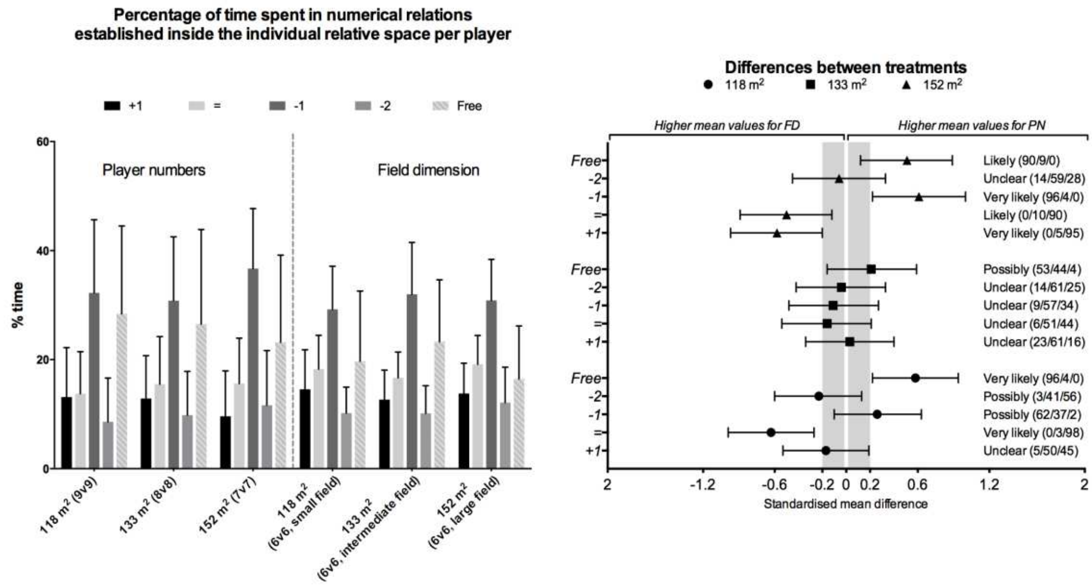

Figure 5 – Left panel - percentage of time spent in various numerical relations established inside the individual relative space per player (118, 133 and 152 m^2). Error bars depict standard deviation. Right panel – standardised mean differences between treatments (player numbers and field dimension) plus quantitative chances of higher or lower differences. Error bars represent 90% confidence intervals and probabilities are reported as percentages of greater/similar/lower values. The shaded area represents trivial differences.

Concerning the numerical relations established across SSCG, most of the time players tended to perform with one fewer teammate than opponents inside their relative spaces per player in all treatments. In most cases, the amount of time played without any other players inside the individual relative space per player was the second most prevalent numerical relation (Figure 5). Differences between treatments were found for the 118 and 152 m^2 relative spaces per player, but not for the 133 m^2 relative space per player where differences were all trivial. In the 118 m^2 relative space per player it is worth noting the moderate difference found for NR(=), with manipulations of field dimensions promoting more time spent playing with equal numbers of teammates and opponents inside the individual relative space per player. A moderate difference was also observed for the NR(free), with a superior amount of time played when relative spaces per player were manipulated through player numbers. In the 152 m^2 relative space per player all numerical relations revealed moderate to small differences with the exception of the NR(-2), where differences between player numbers and field dimensions were trivial. Time spent playing in NR(+1) and NR(=) was slightly higher for manipulations of FD, whereas the time spent playing with NR(-1) and NR(free) was slightly larger for manipulations of player numbers.

4. Discussion

In this study we analysed the influence of manipulations of field dimensions and player numbers on the spatial-temporal characteristics of inter-individual coordination tendencies of under-15 yr old youth football players emerging within the same replicated dimensions ofrelative space per player during SSCG. The dependent variables encompassed the effective relative space per player, radius of free movement, variability of the players' spatial distributions and the numerical relations established in the vicinity of each player. Results showed that, even though manipulations of player numbers and field dimensions may be used to set the same relative spaces per player, emergent interpersonal coordination tendencies of players during each constraining SSCG differed. This finding suggests that players co-adapted to the specific constraints being manipulated in the experimental treatments. This finding fits with the tendency in complex biological systems to self-organise as they encompass a number of components (e.g. players) with the capacity to interact and form emergent patterns of collective behaviours (Davids et al., 2005a; Kelso, 1995; Kugler et al., 1980). In general, during manipulations of player numbers, higher values of the effective relative space per player, radius of free movement and lower spatial distribution variability emerged in all pre-set relative spaces per players, suggesting that each player afforded more space to play and was required to perform in more regular zones of the field than when performing in equivalent areas set through manipulations of FD.

Manipulations of player numbers did not promote meaningful changes in the values of the effective relative space per player and in their radius of free movement. However, the first seemed to be greater when a larger number of players were involved (Table 2). In contrast, when increases of field dimensions were undertaken, the effective relative space per player increased along with concurrent increases in values of distance to nearest opponents. Accordingly, adding extra players to teams performing on a field of constant dimensions seemed to provoke a reorganization of the players. This led them to display a wider dispersion on field to achieve similar interacting patterns of behaviour (i.e., leading to similar amounts of space per player and similar distances to opponents). As performance area dimensions increased, greater effective relative spaces per player were available to be explored with concurrent increases in their radius of free movement.

Similar co-adapting behaviours have been observed in other studies, in terms of inter-team distance values, as a result of field dimensions manipulations (Frencken et al., 2013; Silva et al., 2014c). This modification may have created more possibilities for each player to pass the ball and maintain possession since opponents were further away from ball passing trajectories (B. Travassos et al., 2012; Vilar et al., 2012). Conversely, on smaller performance areas fewer opportunities may have been provided to maintain ball possession due to decreasing distances of opponents to ball trajectories (Vilar et al., 2014). This assumption is corroborated in studies that have analysed the technical determinants of SSCG. Kelly and Drust (2009) and Dellal et al. (2012) observed a greater frequency of tackles, challenges, loss of ball possessions and physical contacts in SSCG played on smaller performance areas.

Another important aspect from this study to retain is that effective relative spaces per player values found for all relative space per player treatments were much smaller than those theoretically set by the simple quotient of the total field area per number of players (Tables 1 and 2). These findings do not corroborate the recommendations of Fradua et al. (2013) for determining the appropriate size of SSCG fields, possibly because they considered the total SSCG field area rather than an effective playing space area inside the SSCG fields. Further studies are needed to clarify this issue considering the effective playing area rather than the total SSCG area and using a broader participants sample (of varied ages and skills).

Concerning the numerical relations established inside each relative space per player treatment, a numerical disadvantage of one player was dominant over time, intersected by periods of time without any teammates or opponents in the vicinity of each player. Larger periods of time under numerical advantage were observed for field dimensions having 118 and 152 m^2 relative spaces per player, but not 133 m^2, where manipulations of field dimensions or player numbers promoted similar values of numerical relations. Larger periods of numerical disadvantage were observed during manipulations of player numbers and the 118 and 152 m^2 relative spaces per player treatments, but not on the 133 m^2 treatment. Additionally, in the 152 m^2 condition, larger periods of time were played under a numerical superiority of one player. The creation of numerical dominance is key for increasing offensive success and defensive stability in competitive team games (Silva et al., 2014e; Vilar et al., 2013).

The lack of a solid theoretical rationale to explain the aforementioned results raises the need for further work clarifying the relationship between player numerical relations and different SSCG formats. A major task here is to scrutinize performance interactions during transitions between attacking and defending phases. Independently, constraints on field dimensions and player numbers clearly provided distinct values of numerical relations in the 118 and 152 m^2 relative space per players. Manipulations of field dimensions elicited a greater number of situations with a numerical advantage whereas player numbers modifications promoted more situations where players stood alone without any other individuals in their action zones, or with a numerical disadvantage of one player.

The spatial distribution of players on field was more irregular for manipulations of field dimensions with larger differences observed for constraints manipulations in the smaller relative spaces per player (118 m^2). Players also displayed more irregular spatial distributions when fewer numbers of individuals performed on fixed field dimensions and when a fixed number of players were involved on fields of smaller dimensions. This finding provides information about the specificity of tactical roles required for each SSCG manipulation. More irregular spatial distributions seem to appeal to more broad tactical roles, while restricted spatial distributions suggested a more structured style of play, according to specific positioning and playing roles. Similar findings where observed by Silva et al. (2014a) for national- and regional-level players performing in SSCG with different field dimensions.

In this study only a small sample of youth players was investigated. Larger samples of participants of varied ages and skill levels should be considered in future studies as well as the manipulation of other relative space per player areas, player numbers (e.g., 3v3, 4v4, 5v5) and field dimensions. The type and number of technical actions performed may also be considered in order to verify whether game behaviours, like shooting or tackling, for instance, occur more often in specific SSCG contexts.

5. Conclusions

This study showed how, at an inter-individual level of analysis, football players' spatial distributions on field can be influenced differently when player numbers or field dimensions manipulations are undertaken. The findings of this study provided a theoretical rationale for explaining why space and player numbers should be manipulated in training tasks, providing relevant implications for enhancing tactical behavioural interactions of developing players. The manipulation of such constraints leads to the specification of different informational sources that invite players to perform functional patterns of behaviour without coaches explicitly prescribing a priori solutions for them (Davids et al., 2005b). Such coordination tendencies can be harnessed by practitioners to lead performers towards stable performance behaviours. Such behaviours should be verified in further studies through the analysis of inter-individual, intra- (e.g., stretch indices, team length, team width, team shape, etc.) and inter-team (e.g., effective playing area, distance between lines-forces, etc.) variables as well as technical actions. One possibility to extend knowledge about performance in SSCG is by cross-checking information on technical actions (e.g., passes, shots, tackles, etc.) with the dynamic behaviours of players and teams (e.g., the direction and type of pass when more space is available to play or when favourable or unfavourable numerical relations emerge during the game).

6. Practical applications

In the context of this study, favouring attacking plays or augmenting defensive pressure could be obtained by decreasing and increasing the effective relative space per player, the players' range of free movement (without opponents) and by promoting favourable or unfavourable numerical relations near the vicinity of each player, respectively. Manipulating player numbers or field dimensions could also be used to shape the depth of players' tactical roles. Playing with fewer players on fields with fixed dimensions or with a fixed number of players on smaller performance areas seemed to elicit more broader spatial distributions and vice-versa.

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