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Original Article

Effects of pitch dimension and skilllevel on the application of space and concentration principles in football small-sided and conditioned games

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Abstract:
Problem Statement: A real challenge to coaches is to design effective practice tasks that adequately represent the competitive environment. In this sense, more studies are needed to investigate constraints manipulation effects on Football specific principles of play representativeness. **Purpose:** To analyse the effects of pitch dimension and skill level on applying offensive and defensive specific principles of play (space and concentration, respectively) during football small-sided and conditioned games. **Approach:** The intra-team coordination was measured through two variables that captured teams' dispersion (width and length). Players were divided into two groups (National or Regional level players) and participated in three different small-sided and conditioned games according to pitch dimension (small, intermediate, and large). **Results:** The pitch dimension (small, intermediate, and large) had a significant effect on length ($F(2, 66) = 7.8$, $p = 0.001$, $\eta2 = 0.19$) and width ($F(2, 66) = 5.4$, $p = 0.006$, $\eta2 = 0.14$) during the offensive phase. During the defensive phase, pitch dimension also had a significant effect on length ($F(2, 66) = 31.4$, $p < 0.001$, $\eta2 = 0.48$) and width ($F(2, 66) = 14.0$, $p < 0.001$, $\eta2 = 0.29$). The skill-level had significant effect on width during both offensive phase ($F(1, 66) = 7.8$, $p = 0.007$ $\eta2 = 0.10$) and defensive phase ($F(1, 66) = 19.9$, $p < 0.001$, $\eta2 = 23.2$). **Conclusions:** The increase of pitch dimension promoted higher dispersion values (width and length) on offensive and defensive phases of play. Additionally, teams have been capable of self-organising due to pitch dimensions' constraints to continue applying the offensive (space) and defensive (concentration) specific play principles.
Key Words:constraints-led approach, representative learning design, action fidelity, task constraints, collective behaviour.

Introduction

It is argued that Small-Sided and Conditioned Games (SSCGs) are representative learning designs that adequately simulate contexts of regular matches and promote similar performance behaviours (Davids, Araujo, Correia, & Vilar, 2013; Pinder, Davids, Renshaw, & Araujo, 2011). Therefore, football coaches frequently use SSCGs in training contexts to simultaneously improve the players' physical conditioning, technical and tactical skills (Aquino et al., 2020; Aquino, Puggina, Alves, & Garganta, 2017; Clemente et al., 2020; Clemente & Sarmento, 2020; Low et al., 2020; Ometto et al., 2018; Ramos et al., 2020).

Although SSCGs has been highly utilised in football training programmes, it could be tricky to verify if players are adequately developing their skills by respecting the principles of play. These game formats could vary in countless manners by manipulating several constraints such as pitch dimension, number of players, rules modification and coach encouragement (Davids et al., 2013). Moreover, different players involved in the same game format could respond differently (Davids, 2015). So, it is essential to continually evaluate if the tasks are suitable to the players' level.

According to a constraints-led approach, coordination patterns emerge from the interaction between organism, environment and task constraints (Davids, Button, & Bennett, 2008; Newell, 1986). Small changes in any of these constraints like manipulating the pitch dimension (tasks' specific constraints), playing while is raining instead of during a sunny day (environmental constraints), or playing with different teammates (organismic constraints) should promote the emergence of different behavioural patterns.

By manipulating these features in SSCGs, practitioners can promote players to develop functional movement solutions through the necessity to continuously co-adapt their actions to different contextual information (Davids et al., 2013). However, it becomes imperative to investigate whether the training tasks are representative of the performance context. The literature has warned about the importance of representative design, supported by the ideas of Brunswik (1956). In this case, it could be assuring training environments whose constraints samples adequately provide key information from the official match (Araujo, Davids, &

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Passos, 2007; Crow, 1957; Pinder et al., 2011). By providing relevant information sources, players could detect similar possibilities for action *(affordances)*(Pinder et al., 2011) that promote specific behaviours similar to those in the formal game. The transfer of acquired behaviours from the training environment to the official performance context can be achieved if the movements, tasks, and problems of the SSCGs were similar to the formal match. There must be action fidelity between SSCGs and the formal game (Stoffregen, Bardy, Smart, & Pagulayan, 2003). Stoffregen et al. (2003) refer to action fidelity when there is a similarity between performance in the simulation environment and behaviours on the simulated system.

The space occupation and the players' interpersonal distance on the pitch are current concerns of coaches, mainly due to the high demands that the modern game requires. However, these behaviours differ when the players are attacking and when they are defending. Costa et al. (2009) proposed the specific tactical principles of attack (penetration, offensive cover, mobility, space and offensive unit) and defence (containment, defensive cover, balance, concentration and defensive unit) in order to assists in the development of players behaviours, since they help to regulate and organise the technical-tactical actions in the game. Thus, when attacking, players should occupy corridors and give depth and width to the team (principle of space). When defending, players should compact the team and consequently close the opposing team playing space (principle of concentration). Therefore, learning and developing these tactical principles of play is vital to play football.

Another critical question is if players with different skill-levels can fulfil the same tactical principles. There is evidence to support the assumption that players of distinct skill-levels behave differently under the same set of environmental constraints (Low et al., 2020; Ramos et al., 2020). On what concerns the tactical determinants of SSCGs, Silva et al. (2014) demonstrated that players of distinct skill-levels display different spatial distribution and movement trajectories on the pitch. More information is then needed about the effectiveness of SSCGs in promoting adequate tactical principles in players of different skill levels.

Therefore, the aim of this study was twofold. First, to analyse the pitch dimension manipulation effect in applying specific principles of play (space and concentration) towards creating or occupying spaces during the offensive and defensive phases. Second, to investigate whether there are differences between skill-levels (national and regional players) in applying specific principles (space and concentration) when varying pitch dimension in SSCGs. We expect changes in key information sources (through pitch dimension manipulations) to promote both teams' adaptative behaviours. Also, skilled teams should self-organise better to maintain the application of space and concentration principles of play.

Material & methods

Participants

Twenty male under-17 football players from two clubs participated in this study. Ten players (aged15.9±0.45 years) from Club X competing at the national level competition were classified as national level of performance (NLP) and ten players (aged16.02±0.42 years) from Club Y competing at the regional level competition were classified as regional level of performance (RLP). All participants had more than three years of playing experience at their respective levels. Players and legal tutors were informed about the procedures of the study and signed an informed consent form. The Ethics Committee of Faculty of Sport of University of Porto approved the protocols (03/2013 CEFADE).

Experimental Design

Each group (NLP and RLP) were divided by their coaches into two technically equivalent teams of five players (one goalkeeper, one defender, two midfielders and one striker). The experimental task consisted of three different 4 vs 4 plus goalkeepers SSCGs formats using 7-a-side football goals, only varying the pitch dimensions, as follows: small (23.8 x 36.8 m, width x length), intermediate (30.6 x 47.3 m, width x length), and large (37.4 x 57.8 m, width x length).

The goalkeepers' area was marked five meters from the goal line and extending across the pitch width to all formats. Several balls were placed around the pitch and promptly provided to the players whenever they left the pitch. The offside rule was not applied.

All games and recovery periods were 7-min duration (ratio 1:1). We consider that this ratio helps to minimise the influence of fatigue in the players. During recovery periods, players rehydrated and recovered actively with a ball (e.g., switching short passes).

Data Collection

All SSCGs were filmed, and each player carried a global positioning tracking device (Qstarz BT-Q1000eX) that captured the participant's 2D positional coordinates at a sampling frequency rate of 10Hz. Pitches coordinates were calibrated using four GPS devices placed in each corner of the pitch for two minutes. The absolute positions of each corner were used to calculate the Cartesian coordinate axis. The formula Haversine (Sinnott, 1984) was used to convert the longitudinal and latitudinal coordinates (spherical) in Euclidean coordinates (planar).

Data analysis

Each team's length and width in the offensive and defensive phases were used to analyse the specific principles of play (space and concentration). The six longest ball possession sequences for each team in each SSCG format were selected, totalling twelve sequences for each condition. For each sequence, the width and length (in meters) for the attacking and defending teams, were calculated across time. Width and length were computed for each second of play as the difference between maximum and minimum values of y- and x-coordinates, respectively (i.e., the distance between the furthest player to the right and furthest player to the left for width, and the distance between the furthest player forward and furthest player backward for length. See Figure I). The average width and length of each sequence were calculated for statistical purposes.

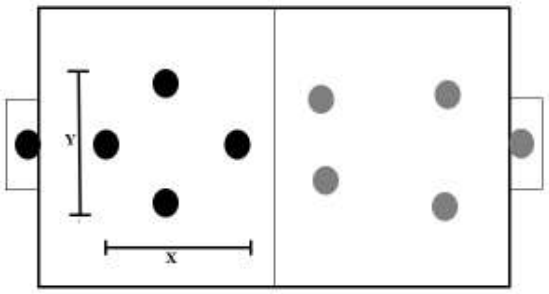

Figure I. *Graphical representation of the collective variable width (y) and length (x).*

Statistical analysis

The effects of pitch dimension and skill level on the team's width and length in offensive and defensive phases were analysed using *Split-plot* repeated measures ANOVAs in SSCGs (3 levels: small, intermediate, and large pitch) and *between-subjects* factor in skill-level (2 levels: national and regional). Whenever differences were found regarding pitch dimension effects, *post hoc* analyses were performed using the Bonferroni adjustment. The significance level was established at 5% ($p< 0.05$). The variable computation and statistical procedures were conducted in MATLAB® R2011b software (The MathWorks Inc, Natick, MA, USA) and SPSS® 20.0 (IBM SPSS Inc., Chicago, USA).

Results

Offensive phase

Figure IIA reveals a uniform increase in the length mean values of NLP (Small: 12.0 ± 1.8; Intermediate: 15.3 ± 2.8 and Large: 19.3 ± 4.9) with increases of pitch dimension, while for the RLP the intermediate pitch registered the higher length mean values (Small: 11.4 ± 3.5; Intermediate: 15.4 ± 6.0 and Large 19.3 ± 5.8).

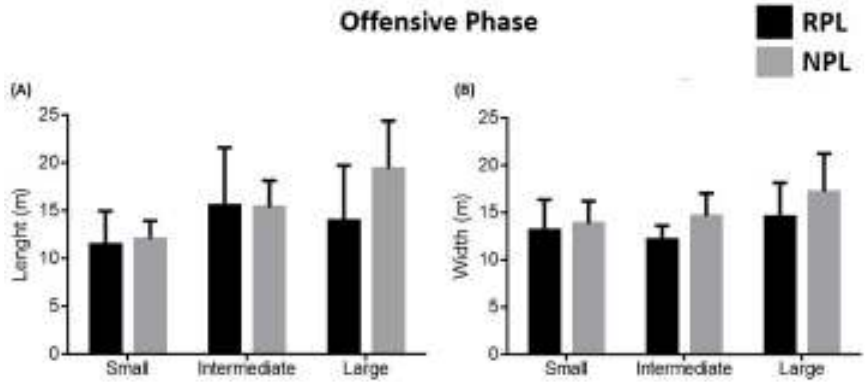

Figure II.*Mean±standard deviation values of length and width according to field dimension (small, intermediate and large) and skill level (NLP and RLP) during the offensive phase.*

The ANOVAs showed a main effect on length for pitch dimension, F (2, 66) = 7.8, p = 0.001, η^2 = 0.19. Bonferroni multiple comparisons revealed that length of teams on small pitch (M = 11.7, SE = 0.91) was significantly lower compared to intermediate (M = 15.4, SE = 0.91, p = 0.018) and large (M = 16.7 SE = 0.91, p = 0.001), but not between the intermediate and large pitches (p = 0.99). No significant effects were found for skill-level neither for interaction effects (see Table I).

Table I. *Main effects of field dimension (small, intermediate and large), skill level (NLP and RLP) and field dimension x skill level interaction on team length and width during the offensive phase.*

		df1	df2	*F*	*p*	*Partial* η^2
Length	Field dimension	2	66	7.803	0.001*	0.191
	Skill level	1	66	3.535	0.064	0.051
	FD x SL	2	66	2.812	0.067	0.079
Width	Field dimension	2	66	5.468	0.006*	0.142
	Skill level	1	66	7.882	0.007*	0.107
	FD x SL	2	66	0.786	0.460	0.023

Note. df1 = degrees of freedom between groups; df2 = degrees of freedom within groups; *F* = result of the ANOVA test; *Partial* η^2 =Effects size.FD = field dimension; SL = skill level *p< 0.05

The mean values of width on NLP (Small: 13.8 ± 2.3; Intermediate: 14.6 ± 2.4 and Large: 17.2 ± 4.0) increased with pitch dimension, while for the width on RLP, the intermediate pitch recorded the lowest average values (Small: 13.0 ± 3.2; Intermediate: 12.0 ± 1.5 and Large: 14.5 ± 3.5) (see Figure IIB).

Significant main effects on width were observed for pitch dimension, *F (2, 66)* = 5.4, p=0.006, η^2=0.14, and skill level, *F (1, 66)* = 7.8, p=0.007 η^2=0.10. *Post hoc* analysis revealed that width on large pitch (M = 15.8, SE = 0.60) was significantly higher compared to small (M = 13.4, SE = 0.60 p = 0.019) and intermediate (M = 13.3, SE = 0.60, p = 0.015) pitches, showing no statistical differences between the small and intermediate pitches. The NLP teams showed greater width (p = 0.007) when compared with the RLP teams. No interaction effect was found (see Table I).

Defensive phase

Figure IIIA reveals a uniform increase in the mean values for length in NLP (Small: 10.5 ± 1.7; Intermediate: 12.2 ± 2.3 and Large: 18.0 ±3.1) and RLP (Small: 11.6 ± 2.7; Intermediate: 14.5 ± 3.9 and Large: 16.8 ± 2.4), with increases in pitch dimension.

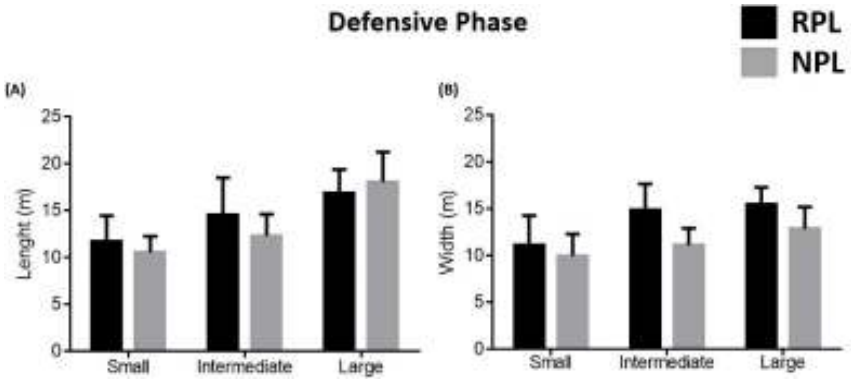

Figure III.*Mean±standard deviation values of length and width according to field dimension (small, intermediate and large) and skill level (NLP and RLP) during the defensive phase.*

The ANOVAs showed a main effect on length for all pitch dimensions, *F* (2, 66) = 31.4, p< 0.001, η^2 = 0.48. That is, the length of teams on small pitch (M = 11.1, SE = 0.57) was lower compared to intermediate pitch (M = 13.4, SE = 0.57, p = 0.006) and large (M = 17.4, SE = 0.57, p <0.001) and the length of the teams in the intermediate pitch was significantly lower compared to large pitch (p <0.001). There were no interaction effects between pitch dimension and skill-level (see Table II).

Table II. *Main effects of field dimension (small, intermediate, and large), skill level (NLP and RLP) and field dimension x skill level interaction on team length and width during the defensive phase.*

		df1	df2	*F*	*p*	*Partial* η^2
Length	Field dimension	2	66	31.46	0.000**	0.488
	Skill level	1	66	1.305	0.257	0.019
	FD x SL	2	66	2.330	0.105	0.066
Width	Field dimension	2	66	14.00	0.000**	0.298
	Skill level	1	66	19.96	0.000**	0.232
	FD x SL	2	66	1.823	0.170	0.052

Note. df1 = degrees of freedom between groups; df2 = degrees of freedom within groups; *F* = result of the ANOVA test; *Partial* η^2 = Effects size **p< 0.001

The mean values of width in NLP (Small: 9.97 ± 2.3; Intermediate: 11.0 ± 1.8 and Large: 12.8 ± 2.3) and RLP (Small: 11.1 ± 3.1; Intermediate: 14.8 ± 2.7 and Large: 15.4 ± 1.7) increases with pitch dimensions (see Figure IIIB). There were significant main effects on width for pitch dimension, $F\ (2,\ 66)$ = 14.0, p< 0.001, η^2=0.29, and skill level, $F\ (1,\ 66)$ = 19.9, p <0.001, η^2=23.2. *Post hoc* analysis revealed that teams' width on small pitch (M = 10.5, SE = 0.49) was significantly lower compared to intermediate (M = 12.9, SE = 0.49, p = 0.001) and large (M = 14.1, SE = 0.49, p <0.001) pitches. The NLP teams showed a lower width (p <0.001) when compared with the RLP teams.

Discussion

Planning, organising, and executing football training exercises that adequately replicate the competitive environment has been a challenge for coaches. Thus, this study aimed to investigate the effects of pitch dimension and skill level constraints on applying the specific principles of space and concentration during SSCGs. For this purpose, the length and width of the teams were analysed during offensive and defensive phases of play.

The results confirmed our hypothesis that different formats of SSCGs promote adaptations of teams' collective behaviours to maintain the principles of play application. When attacking, players expanded in width (to occupy the lateral lines of the pitch) and length (to provide depth to the team) to create spaces and therefore, facilitate the performance of an individual or collective actions. In contrast, when defending, teams formed a compact unit by playing with closer lines to hinder the opponent's attack. We can infer that players self-organise according to their specific functions to ensure a balanced occupation of the pitch during the offensive and defensive phases. Moura, et al. (2012) reported the same behaviour during an official game between the Brazilian Championship teams. By analysing coverage area and teams spread, they identified an increased effective playing area during the attack as the inverse behaviour during the defensive phase. Considering these results, it seems to have congruence between the principles applied in an official football match and the SSCGs here analysed. So, it is plausible to conclude that tactical principles are not affected by space's manipulations, since the internal logic of the game remains unchanged. Manipulating the individual playing area (IPA) in SSCGs by changing the number of players, Chung, et al. (2019) verified higher values for length and width during the offensive phase when compared with defensive phase. Is important to recognise that altering the IPA through the manipulation of pitch dimension or number of players (Silva et al., 2015) allows athletes to use different contextual information permitting the detection of new affordances (opportunities for action) (Araújo, 2009). Thus, providing new co-adaptive behaviours on intra-team coordination (Silva, Garganta, Araujo, Davids, & Aguiar, 2013). Despite this, our study revealed that the IPA's variation by manipulating the pitch dimension induced teams to explore different available spaces and promoted adaptations to continue performing the offensive and defensive principles. Thus, players adapted their collective behaviours by continuously interacting with their teammates and opponents' space, positioning, and movements, all constrained differently according to the pitch dimension (Davids, Araujo, Correia & Vilar, 2013; Passos, Araujo, & Davids, 2013).

Our results revealed that increasing the pitch dimension seems to expand the teams' length and width values both in the offensive as in the defensive phase. Silva, Duarte, et al. (2014) showed similar results when increasing the field dimension promoted larger playing areas of the teams, independently from the skill level. These finds suggest that the larger pitch of SSCGs used in this study can be manipulated in an initial learning phase, to develop offensive situations, once the teams found adequate and favourable conditions in the pitch with larger dimensions, i.e. space and consequently time to conduct their technical-tactical actions. For example, Costa,, et al.(2011) observed that players' behaviours were also influenced by changes in the pitch dimensions, especially regarding the defensive organisation. In their larger pitch format, teams presented difficulty to manage the play space and carry out tactical actions related to defensive principles. In the defensive phase, the teams' width in small pitch was significantly lower than in intermediate and large pitches. The pitch size constrains how the teams compacted to occupy and restrict effective spaces of play to difficult the progress of adversary attacks. The study conducted by Costa et al. (2011) demonstrated that smaller pitches allow players to perform more actions to defend the ball carrier and obstruct the opponents' passing lines. In this sense, it seems that the application of a pitch with a smaller dimension will be an adequate tool for the acquisition of defensive behaviours. However, it does not mean that attacking situations cannot be trained into smaller pitches. For example, Kelly and Drust(2009) verified technical actions in SSCGs with different pitch dimensions. They observed more tackles on smaller pitches, but players also performed more shots, a necessary technical action during the offensive phase.

About the skill-level analysis, the NLP showed a higher value of width in the offensive phase and lower values in the defensive phase compared with the RLP. The NLP presented better patterns of offensive and defensive collective behaviours related to the specific principles of space and concentration than the RLP in all pitch formats of SSCGs. Castellano, et al.(2013) also identified similar behaviours in a high-level football team during six competitive matches against upper and lower-level opponents. The authors found that the team often had high values of length, width, and surface area when confronted with weaker teams in the offensive phase. However, in the defensive phase, the team presented a higher length, width, and surface area when confronted with stronger opponents. Other studies comparing different skill-level tactical performances reported that high-

level players demonstrate better collective behaviours in SSCGs. In Silva, Duarte et al. (2014)research, the more skilled players tend to assume an elongated playing shape in larger fields and present higher variability in distances to the opponents without any specific instructions. Silva, Aguiar, et al. (2014) found that highly skilled players could demonstrate more variability in spatial distributions than less skilled players during small and intermediate pitch sizes. When comparing differences between age groups in dispersion variables, the older teams usually show higher values than younger teams (Barnabé, Volossovitch, Duarte, Ferreira, & Davids, 2016; Folgado, Lemmink, Frencken, & Sampaio, 2014; Olthof, Frencken, & Lemmink, 2015). Thus, the results suggested that the NLP players seem to adapt better by self-organizing and adjusting their behaviours in the presence of different types of constraints when compared to RLP players.

Following the results observed in this study, I t can be affirmed that players of both skill-levels can co-adapt in the task constraints' function. In all three SSCGs (small, intermediate and large pitches), players maintained the specific principles of play (space and concentration), during the offensive and defensive phase. These SSCGs seems to be representative learning environments to develop collective tactical behaviours, ensuring functionality and action fidelity concerning formal game dynamics (Davids et al., 2013; Stoffregen et al., 2003).

Conclusions

The football-specific principles of play (space and concentration) remained unchanged in SSCGs of different sizes. The offensive and defensive phases implicated different tactical behaviours. During the attack, observed dispersion values (length and width) were higher than during the defence. The increase in the pitch dimensions also increased the values of length and width. Therefore, the manipulation of IPA through manipulating the pitch dimension influences the emergence of tactical coordination processes in SSCGs. Although showing the same tendencies, players of different skill levels respond differently to the same constraints of the task. The NLP teams seem to be more sensitive to changing the pitch dimensions and applying offensive and defensive play principles. From a pedagogical perspective, our results suggests that these formats of SSCGs are representative contexts of the formal game regarding space and concentration principles. The manipulation of the pitch dimension on SSCGs stimulates players to co-adapt by increasing or decreasing play space. The players continuously readjusted the distance between themselves to maintain the functional and efficient tactical coordination processes in both phases.

Smaller pitches are useful tools to incorporate the coaches' training plan to improve the defensive principle (concentration), while larger pitches can improve the offensive principle (space). It should be emphasised that playing in larger pitches does not compromise the need to adjust the spaces when it defends and to play in smaller pitch also does not compromise the offensive phase. Thus, coaches should be sensitive to designing the training tasks using these different pitch formats according to their team and players' necessary goals. The coaches should be aware of the factors they intend to develop and what results they want to achieve in each step. Since SSCGs are representative tasks of the formal game, they can be used for tactical behaviour development and provide more active participation in the game concerning official matches with greater space and number of players. Consequently, it also promotes a higher involvement of participants in the consistent application of offensive and defensive principles. Therefore, the SSCGs seems to be an adequate instrument for the coach usageto develop the application of the specific principles of play analysed in this study.

Conflicts of interest: The authors do not have any conflicts of interest to declare.

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