

Influence of pitch length on inter- and intra-team behaviors in youth soccer

Julen Castellano^{1*}, Eneko Fernández¹, Ibon Echeazarra¹, Daniel Barreira² and Julio Garganta²

¹ University of Basque Country (UPV/EHU) (Spain).

² Centro de Investigação, Formação, Inovação e Intervenção em Desporto, Universidade do Porto (Portugal).

Título: Influencia de la longitud del campo en los comportamientos inter e intra-equipo en jóvenes jugadores de fútbol.

Resumen: El comportamiento táctico puede verse afectado por los cambios en los formatos de juegos reducidos (SSG). El objetivo del presente estudio fue analizar la influencia de diferentes longitudes del terreno de juego en formatos SSG-de-7 jugadores en jóvenes futbolistas. 14 jugadores masculinos de fútbol en cada grupo de edad (13 y 14 años, U13 y U14, respectivamente) se dividieron en dos equipos de siete jugadores, quienes jugaron en cuatro SSGs de 7 minutos de duración, intercalados con 4 minutos de recuperación pasiva. La única modificación en el formato SSG fue longitud del terreno: 60 m (SSG60), 50 m (SSG50), 40 m (SSG40) y 30 m (SSG30), mientras que la anchura del campo de 40 m se mantuvo constante. Las variables utilizadas para caracterizar el comportamiento colectivo se agruparon en: a) variables intra-equipo, es decir, la longitud del equipo (L), ancho del equipo (W), el área efectiva de juego del equipo o *convex hull* (CH), y el *stretch index* (SI); y b) las variables inter-equipo, es decir, la distancia entre los centroides (DC), la longitud de los dos equipos (L2), la anchura de los dos equipos (W2), envolvente convexa de los dos equipos (CH2), y el índice de estiramiento de los dos equipos (SI2). Los resultados revelan diferentes comportamientos intra e inter-equipo de acuerdo al formato de SSG y la edad del jugador. Las variables L, CH, SI, DC, L2, CH2, y SI2 aumentaron con el incremento en longitud del terreno, mientras que W y W2 mostraron sólo cambios mínimos. Las diferencias fueron mayores en el grupo U13, lo que sugiere que los jugadores más jóvenes fueron más propensos a variar su comportamiento colectivo en respuesta a los cambios de alargar el terreno de juego, inter-tarea, especialmente en los campos más largos (SSG50 y SSG60). Por el contrario, utilizando el análisis de la entropía, mayor imprevisibilidad de comportamiento del equipo se observó en el grupo U14, intra-tarea, en comparación con el grupo U13. En general, los resultados sugieren que las respuestas a la limitación de las tareas, tales como la modificación de la longitud del espacio y el espacio relativo de juego, son dependientes de la edad (experiencia, habilidad) y esto es algo que los entrenadores deben tener en cuenta al diseñar los SSGs para desarrollar comportamientos tácticos colectivos.

Palabras clave: Constreñimiento de tareas; comportamiento táctico; dispositivos GPS; deportes de equipo; entrenamiento.

Abstract: Tactical behavior could be affected by changes in small-sided game (SSG) formats. The aim of the present study was to analyze the influence of different pitch lengths during 7-a-side SSGs played by young football players. Fourteen male soccer players in each age group (13 and 14 years old, U13 and U14 teams) were divided in two teams of seven players who played four SSGs of 7 minutes, interspersed with 4 minutes of passive recovery. The only modification to the SSG format was pitch length: 60 m (SSG60), 50 m (SSG50), 40 m (SSG40), and 30 m (SSG30), while the width of the field was kept constant at 40 m. The variables used to characterize collective behavior were grouped in a) intra-team variables, namely, team length (L), team width (W), effective area of team play or convex hull (CH), and stretch index (SI); and b) inter-team variables, namely distance between centroids (DC), length of both teams (L2), width of both teams (W2), convex hull of both teams (CH2), and stretch index of both teams (SI2). Our results revealed different intra and inter-team behaviors according to SSG format and player age. L, CH, SI, DC, L2, CH2, and SI2 all increased with increasing pitch length, while W and W2 showed only minimal changes. The differences were greater in the U13 group, suggesting that younger players were more likely to vary their collective behavior in response to changes to pitch length, inter-task, particularly in the longer pitches (SSG50 and SSG60). Conversely, using the analysis of the entropy, greater unpredictability of tactical behavior was observed in the U14 group, intra-task, compared with the U13 group. Overall, the findings suggest that responses to task constraints, such as modifications to pitch length and accordingly relative area of play, are dependent on age (experience, skill) and this is something coaches should consider when designing SSGs to develop team tactics.

Key words: Task-constraints; tactical behavior; GPS device; team sports; coaching.

Introduction

Conditioned or small-sided games (SSGs) are a crucial component of soccer training programs (Casamichana, San Román, Calleja y Castellano, 2015). These sub-phases of the full 11-a-side game enable coaches to simultaneously address various training objectives related to technical skills, physical fitness, and psychological aspects (Halouani, Chtourou, Gabbett, Chaouachi, & Chamari, 2014; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011).

SSGs have different formats in which one or more aspects of the official game are modified, such as pitch size (Casamichana & Castellano, 2010), number of players per team, direction of play (Castellano, Casamichana & Dellal,

2013), and number of touches (San Román-Quintana et al., 2013). They may also involve variations in training prescriptions, such as number of series, repetitions, etc. (Casamichana, Castellano, & Dellal, 2013). It is well-established in the scientific literature that SSGs have an effect on physical, physiological, and technical responses (Clemente, Couceiro, Martins, & Mendes, 2012; Hill-Haas et al., 2011). How constraints in the tasks affect the tactical performance of teams as a whole (Gréhaigne & Godbout, 2013) is growing interest, (Folgado, Lemmink, Frencken, & Sampaio, 2014; Silva, Duarte, Sampaio, Aguiar, Davids, Araújo, & Garganta, 2014), suggesting that unpredictability of play increases with age and skill. Researchers (Duarte, Araújo, Correia, & Davids, 2012) are using ecological dynamics to analyze interactions between performers and their environment in team sports, proposing an approach to analyze team performance based on collective behaviors rather than on the sum of individual behaviors (Silva, Garganta, Araújo, Davids, & Aguiar, 2013). In addition, the literature

*** Correspondence address [Dirección para correspondencia]:**

Julen Castellano. Faculty of Education and Sport. University of Basque Country (UPV/EHU). C/ Lasarte 71, 01007. Vitoria (Spain).
<http://orcid.org/0000-0001-5167-5284>.
E-mail: julen.castellano@ehu.eus

describes several useful frameworks for studying intra- and inter-team behavior and dynamics in SSGs (Folgado, Lemmink, Frencken, & Sampaio, 2014; Sampaio & Maças, 2012).

Advances in technology and access to global positioning system (GPS) tracking devices have enabled the collection of large volumes of training data (Castellano, Silva, Usabiaga & Barreira, 2016; Travassos, Vilar, Araújo, & McGarry, 2014b) and expanded the possibilities for interpreting team performance in 11-a-side soccer (Memmert, Lemmink, & Sampaio, 2016). Moreover, numerous studies have shown how the use of task constraints in training situations leads to changes in indicators of collective performance. Frencken, Van Der Plaats, Visscher, and Lemmink (2013), for instance, showed how modifications to pitch length and width led to changes in lateral and longitudinal inter-team distances in 4-a-side (4v4) SSGs, while Silva et al. (2014b) found that different numerical relations between competing teams (5v5, 5v4, and 5v3) were associated with variations in inter-individual and intra- and inter-team tactical behaviors. In a study of 5v5 SSGs, Travassos, Gonçalves, Marcelino, Monteiro, and Sampaio (2014a) showed that increasing the number of scoring targets from two to six increased the distance between the geometric centers (centroids) of the teams, producing different spatial relations between opposing players. In another study of the same format, modifications to scoring targets and goalkeepers and the use of outer-floaters led to co-adaptive team changes reflected by variations in spatial dispersion, team shape, and distances between players and direct opponents (Castellano et al., 2016). Finally, although numerous studies have shown that game modifications result in acute improvements (e.g., Sampaio & Maças, 2012) it would be interesting to analyze whether the inclusion of such modifications in suitably designed training programs would result in lasting improvements over time.

Obviously, age, experience, and skills are all important factors to consider when analyzing the effects of SSGs on tactical behavior. Consistent with an ecological dynamics approach (Seifert, Button, & Davids, 2013), use of the same task constraints in training sessions involving players with different levels of expertise could lead to the emergence of different tactical behaviors (Silva et al., 2014 a, b & c). More skilled players tend to form a larger team shape, which could be interpreted as a strategy for creating space (Sampaio & Maças, 2012; Silva et al, 2014b). Folgado et al. (2014), using player length per width ratio measurements, showed how the shape of teams varied in different SSGs according to player age and numbers. In a more recent study, Barnabé, Volossovitch, Duarte, Ferreira, and Davids (2016) reported greater synchronization between offensive and defensive surface areas and team width in older players. However, information on the effects of different SSG formats (or task constraints) on tactical behavior is still lacking. It would be interesting to identify task constraints (e.g., changes to absolute playing area) that do not change the effective playing area (Castellano et al., 2013), i.e., the area of play covering by the field-players, in order to help coaches recreate training

conditions as similar as possible to competition situations when this is priority.

Apart from understanding how modifications to task constraints trigger changes in collective behavior, coaches might also benefit from learning how these behaviors fluctuate during the application of the constraints. Silva et al (2014b), for example, found fewer variations in the performance of younger, less expert players, suggesting that unpredictability of play increases with age and skill. Unpredictability of individual and tactical behavior could thus serve as a measure of expertise or improvement over time or as a talent spotting tool.

In an attempt to add to the limited body of empirical research on the effects of different constraints applied in SSGs and their influence on player relationships, we sought to analyze team tactical patterns that emerge in response to changes in pitch length. The specific aim of the study was to investigate age-related responses in under-13 (U13) and U14 soccer players during SSGs in which the only variable modified was pitch length. Our findings could help coaches to better understand and shape tactics in teams of different ages and skill levels through simple task manipulations.

Methods

Participants

The participants were twenty-eight U13 and U14 boys from a grassroots soccer academy competing in the second division of the Spanish National League. There were fourteen U13 players (mean \pm *SD*, age: 13.5 \pm 0.3 years, height: 157.1 \pm 9.6 cm, body mass: 45.3 \pm 6.2 kg, maximal velocity [V_{max}]: 24.6 \pm 1.3 Km h⁻¹) and fourteen U14 players (mean \pm *SD*, age: 14.3 \pm 0.3 years, height: 171.3 \pm 6.7 cm, body mass: 58.8 \pm 6.8 kg, V_{max} : 28.6 \pm 1.1 Km h⁻¹). They had been training at the same club and competing for an average of three years before the study. They trained for 90 minutes three times a week and played a weekly 90-minute 11-a-side football match.

The players were all informed about the objectives, requirements, and potential benefits and risks of the study. Informed consent authorizing participation was obtained from all players and their parents. All procedures complied with the principles of the Declaration of Helsinki and were approved by the ethics committee at the University of the Basque Country.

Intra- and inter-team variables

Intra-team behaviors were studied by analyzing team dispersion measurements, namely, team width (W), team length (L), convex hull (CH), and stretch index (SI). W was defined as the distance between the two players furthest apart across the width of the pitch, while L was defined as the distance between the two players furthest apart along the length of the pitch (Lemmink, Delleman, & Visscher, 2011).

The effective playing area was represented by the CH formed by the positions of the players in each team (Moura et al., 2013). SI was calculated as the mean distance between each player and the centroid of their team, which was calculated as the average position of all outfield players on the team. Inter-team interactions were assessed by measuring a) the distance between the centroids of the two teams (DC), b) the length of the two teams (L2), c) the width of the two teams (W2), d) the convex hull of the two teams (CH2) and e) the stretch index of the two teams (SI2). DC was calculated as the mean distance between the teams' centroids, W2 as the furthest distance between any two players across the width of the pitch (i.e., regardless of the team to which they belonged), and L2 as the furthest distance between any two players along the length of the pitch. The following variables were used to calculate player dispersion: 1) effective playing area of both teams combined (CH2), calculated as the CH formed by all 12 field players, and 2) SI2, calculated as the mean distance from each of the 12 players to a single centroid for the two teams.

Small-sided games

The participants all played four 7v7 SSGs in which the only variation was pitch length. The four lengths used were 60 m (SSG60), 50 m (SSG50), 40 m (SSG40), and 30 m (SSG30), which, with a pitch width of 40 m in all cases, corresponded to an absolute pitch size of 2400 m², 2000 m², 1600 m², and 1200 m², respectively, and a relative space per field-player of 200 m², 167 m², 133 m², and 100 m². Each team was composed of six outfield players and one goalkeeper (Gk+6:6+Gk). The aim of the SSGs was simply to score more goals than the other team using two 7-a-side targets (6 * 2 m, width * height). All the games were played on the same artificial grass pitch. Each SSG lasted 7 minutes and the games were separated by 4 minutes of passive recovery.

Procedures

The SSGs were played in two separate sessions (U13 and U14), each preceded by a standard 15-minute warm-up. In order to minimize potential imbalances between teams and ensure maximum equivalence, two players from the same position switched teams after each game. Both teams played with the same formation: one goalkeeper, three defenders, two midfielders, and one forward (1-3-2-1). The standard rules of 11-a-side football were applied, also off-side rule.

The players were familiarized with the different SSG formats. They did not take part in any intense physical activity in the 48 hours prior to the games. The order of games was established randomly. Each SSG lasted 7 minutes and was followed by a rest period of 4 minutes during which players were allowed to drink fluids *ad libitum*. All the players were advised to maintain their normal diet, with special em-

phasis placed on a high intake of water and carbohydrates. Several balls were distributed around the edge of the pitch to maximize effective playing time (Casamichana et al., 2010).

The players' positions were recorded using portable GPS devices operating at a sampling frequency of 10 Hz (Minimax S4, Catapult Innovations). The technology used to collect the GPS data has been previously validated and shown to be reliable for monitoring soccer players (Castellano, Casamichana, Calleja, San Román & Ostojic, 2011; Castellano et al., 2016). The GPS had good satellite connectivity (mean \pm SD number of connected satellites during games: 9.3 ± 0.4).

The performance area used for all the SSG formats was calibrated with the coordinates of 10 GPS devices positioned in each corner of the largest pitch (SSG60) for approximately 5 minutes. The absolute coordinates of each corner were calculated as the median of the recorded time series, providing measurements that were robust to the typical fluctuations of GPS signals. Longitudinal and latitudinal (spherical) coordinates were converted to Euclidean (planar) coordinates.

Statistical analysis

Data are presented as means \pm SD (or pooled SD when necessary). Data were analyzed for practical significance using magnitude-based inferences (Hopkins et al., 2009). Between-group effect sizes with 95% confidence intervals were calculated using pooled SDs. Threshold values for Cohen effect sizes (Cohen, 1998) were set at < 0.2 (trivial), $0.2-0.6$ (small), $0.6-1.2$ (moderate), $1.2-2.0$ (large), and $2.0-4.0$ (very large). Statistical significance was set at $p < .05$. Approximate entropy (ApEn) measures (Silva, Duarte, Esteves, Travassos, & Vilar, 2016) were used to assess unpredictability of L2-, W2-, CH-, and DC-related behaviors during the four SSGs (Duarte et al., 2013). To strengthen the consistency of the entropy values (Silva et al. 2016), the m and r parameters were set at 2, 3, and 4, and 0.1, 0.2, and 0.3, respectively. N was set at 4200 data points (i.e., the length of compound positional variables in the time series corresponding to each 7 minutes, 7 min * 60 sec * 10 frames, of play analyzed per SSG). A decrease in entropy reflects a decrease on unpredictability because the minimum quantity of information needed to describe the system was also reduced. Thus, the system behaviour becomes more predictable, presenting less variability (Silva et al., 2016). Data analysis was performed using SPSS version 22.0 for Windows, (SPSS Inc., Chicago, IL, USA) and *Excel* sheets for *Windows* 7.

Results

Results are presented as mean \pm SD for W, L, CH, and SI for the four SSG formats and teams (U13 and U14). W values were higher than L values in all formats except SSG60 in the U13 category. The values for all the other variables were higher for U13 than U14 players in all four SSG formats.

Figure 2 (U13) and Figure 3 (U14) show the standardized mean differences and confidence intervals for L, W, CH, SI, and DC for the four SSG formats. As can be seen, a reduction in pitch length was accompanied in a reduction in all variables in both age categories. It is noteworthy that although the effects for W were trivial or inexistent, the differences for the rest of the variables were meaningful, with small to moderate effect sizes observed in most cases. Finally, the differences were more pronounced for U13 than for U14.

Figure 4 shows a comparison of the above results for the U13 and U14 teams. As mentioned above, no significant differences were found for W, but the effect of the increase in pitch length on all the other variables was more pronounced in the younger team.

Table 1 shows the results for L2, W2, CH2, and SI2 together with the effect size (*Cohen's d*) comparing the U13 and U14 groups. W2 varied very little between the four SSG formats in both age groups. The differences between the groups increased with increasing pitch length for L2, CH2, and SI2, but remained similar for W2.

Finally, Figure 5 shows the mean results for the distribution of the three *r* values (0.1, 0.2, and 0.3) and the three *m* values (2, 3, and 4), graphically depicting the different levels of complexity of the inter-teams' collective behavior in terms of L2, W2, CH2, and SI2 during the four SSGs. Almost in all small-sided games (with exception of the SSG30) the entropy values of the variables were higher in U14 with respect to U13.

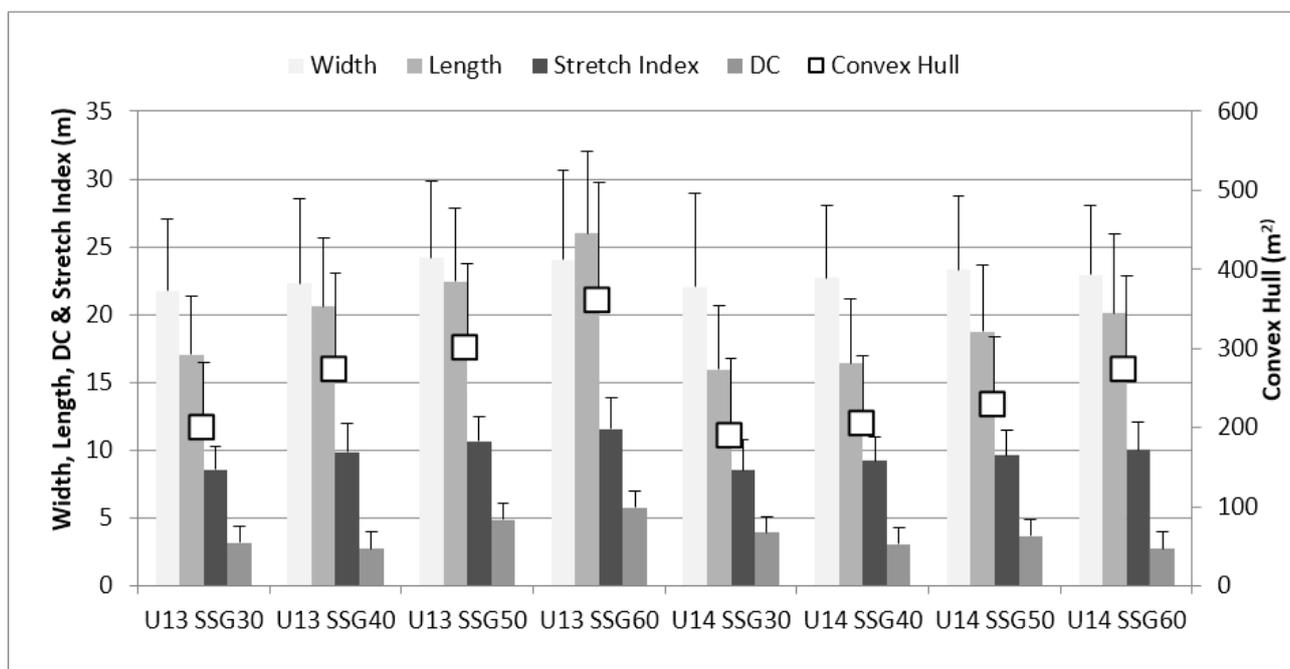


Figure 1. Mean \pm SD team width, team length, distance between centroids, convex hull, and stretch index for under 13 (U13) and U14 players using four 7v7 small-sided game (SSG) formats in which the pitch length was varied from 30 m (SSG30) to 60 m (SSG60).

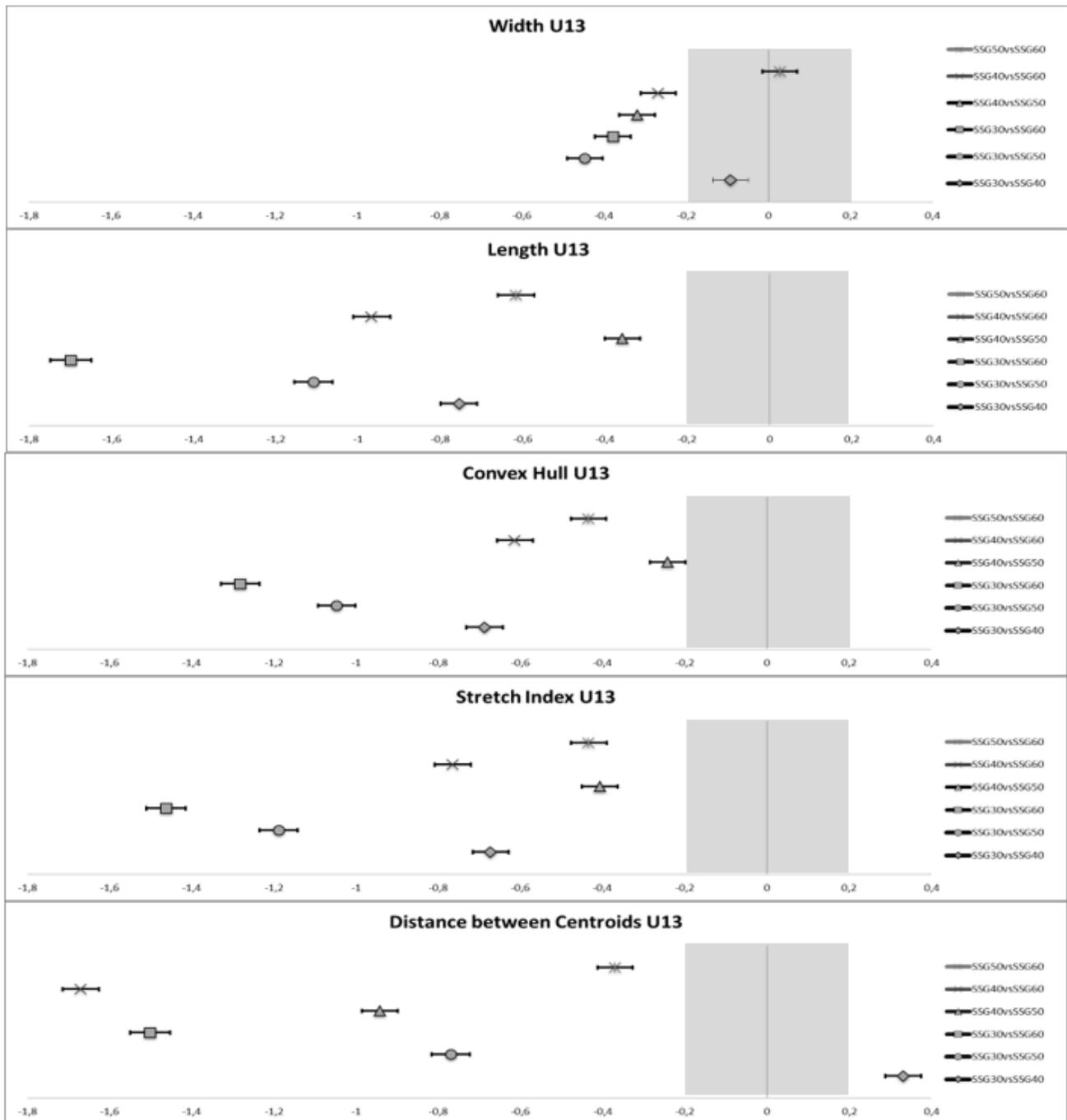


Figure 2. Standardized mean differences and confidence intervals for team length, team width, convex hull, stretch index, and distance between centroids for U13 players using four SSG formats in which pitch length was increased from 30 m (SSG30) to 60 m (SSG60).

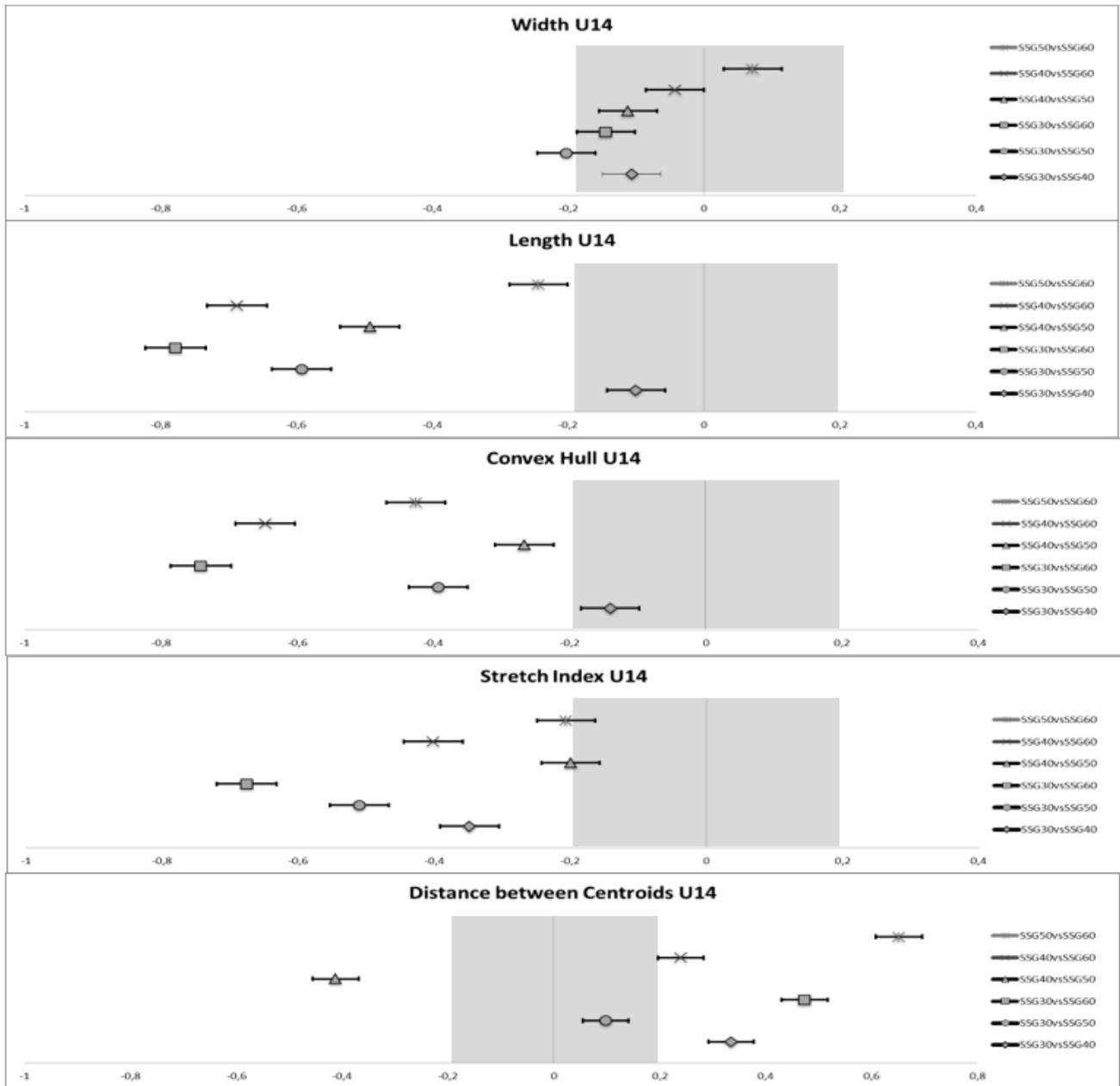


Figure 3. Standardized mean differences and confidence intervals for team length, width, convex hull, stretch index, and distance between centroids for U14 players using four SSG formats in which pitch was increased from 30 m (SSG30) to 60 m (SSG60).

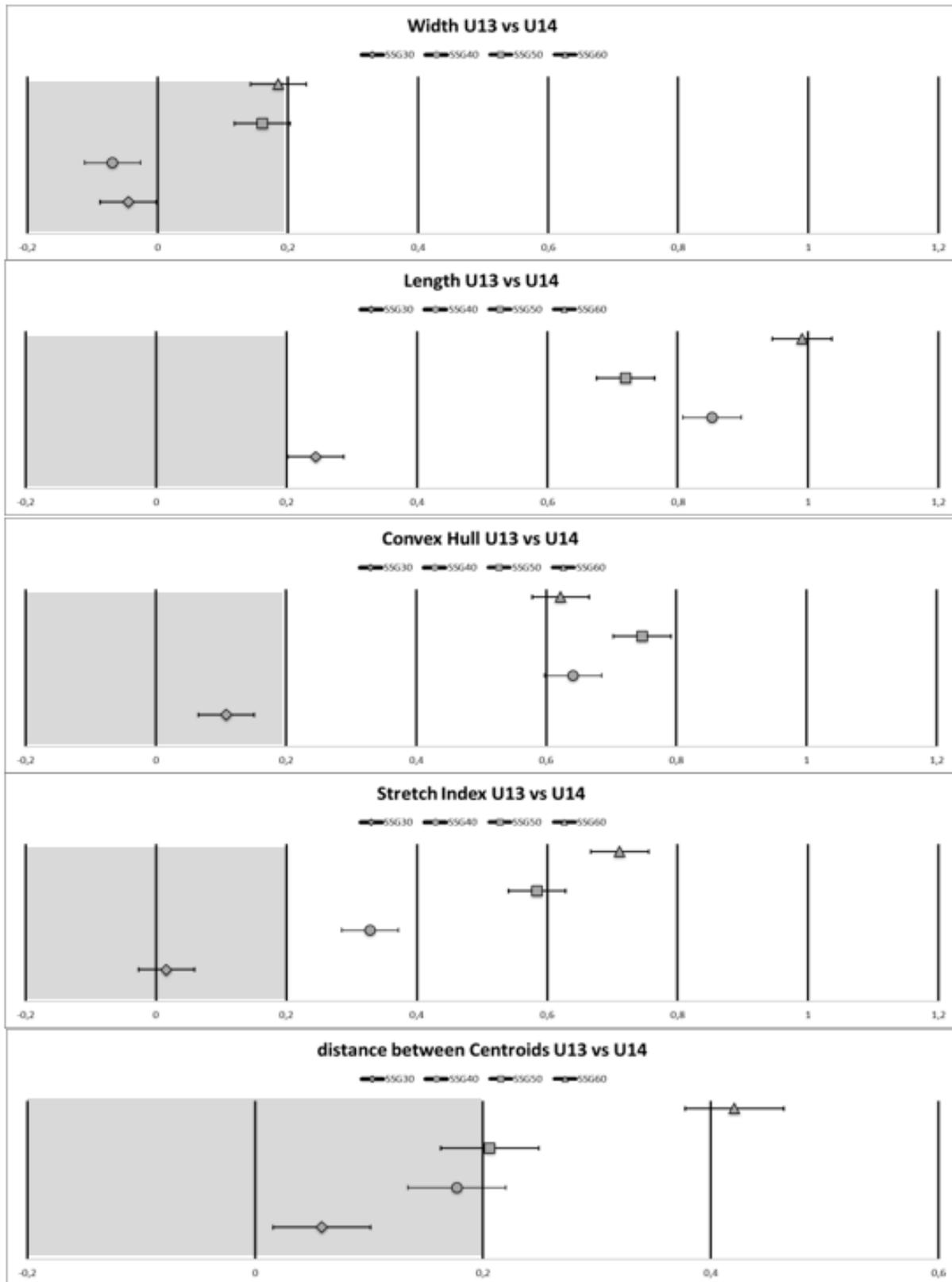


Figure 4. Standardized mean differences and confidence intervals for team length, team width, convex hull, stretch index, and distance between centroids for U13 players versus U14 players using four SSG formats in which the pitch length was increased from 30 m (SSG30) to 60 m (SSG60).

Table 1. Mean \pm SD L2, W2, CH2, and SI2 and effect size (Cohen's *d*) between U13 and U14 teams for each variable and condition.

		W2 (m)		L2 (m)		CH2 (m ²)		SI2 (m)	
		U13	U14	U13	U14	U13	U14	U13	U14
SSG	Mean	25.3	26.6	21.5	20.5	314,4	320,2	8,7	8,9
SSG30	SD	4.8	6.7	3.9	3.8	81,3	98,8	1,2	1,5
	Cohen's <i>d</i>	-0.214		0.260		-0.065		-0.186	
SSG40	Mean	26.3	26.7	24.9	20.5	414,5	327,1	9,9	9,4
	SD	5.4	4.1	4.9	4.6	124,2	81,6	1,5	1,2
	Cohen's <i>d</i>	-0.083		0.920		0.831		0.422	
SSG50	Mean	28.2	26.9	27.3	22.3	486,5	351,2	10,9	9,8
	SD	4.9	5.3	4.5	4.5	107,1	103,6	1,2	1,5
	Cohen's <i>d</i>	0.245		1.097		1.284		0.808	
SSG60	Mean	28.8	26.3	32.3	23.4	580,5	398,8	11,7	10,1
	SD	6.4	4.5	6.3	5.1	186,2	132,5	1,8	1,7
	Cohen's <i>d</i>	0.457		1.540		1.124		0.930	

Note: L2 is maximum length of the two teams; W2, maximum width of the two teams, CH2, convex hull of the two teams, and SI2 stretch index of the two teams. SSG30/40/50/60 refers to small-sided games with a pitch length of 30/40/50/60 m.

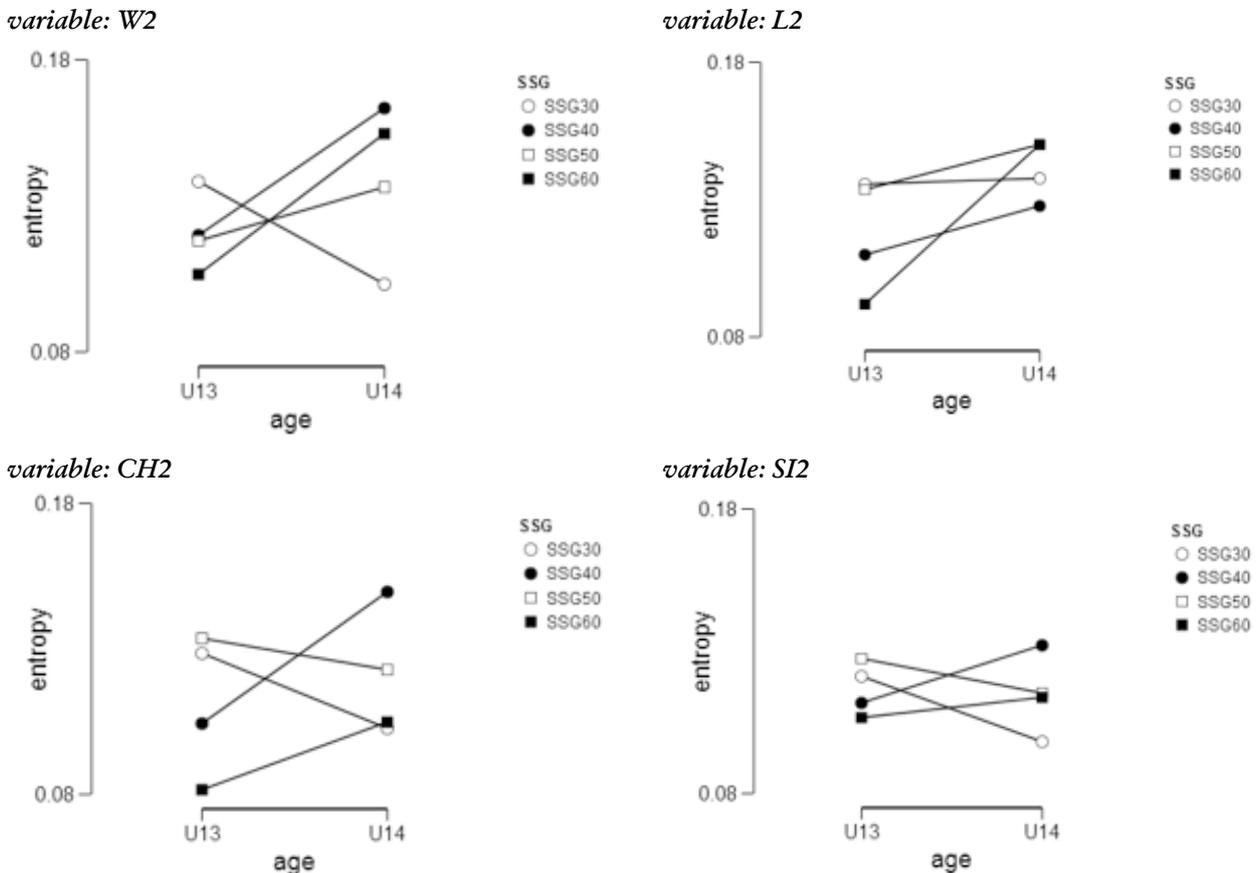


Figure 5. Distribution of approximate entropy values corresponding to the four collective behaviors related to team length (L2), team width (W2), convex hull (CH2), and stretch index (SI2) for the U13 and U14 teams in the four small-sided games (SSGs), where the number following SSG refers to the pitch length in meters.

Discussion

This study examined the effects of changes to pitch length on the collective tactical behaviors of U13 and U14 players in 7v7 SSGs. Our findings largely show that the teams co-adapted differently according to pitch length (the task con-

straint applied) and also reveal differences between U13 and U14 players, with the older players exhibiting more stable behavior. A better understanding of positional variables could lead to their use as reliable performance and development indicators to help coaches design pertinent tasks and training drills.

It is not easy to compare our results with those of other studies due to differences in pitch size, number of players (e.g., 3v3 and 4v4 in Folgado et al., 2014), and/or the ages (or expertise) of the players analyzed (e.g. amateur adults in Castellano et al., 2016 and Frencken et al., 2013; U16, U17, and U19 players in Barnabé et al., 2016; and, U17 and U19 players in Olthof, Frencken, & Lemmink, 2015). In general, however, our findings support previous reports of different co-adaptation patterns in response to different task constraints, such as number of players (Silva et al., 2014c), pitch size (Silva et al., 2014b), type and number of goal targets (Travassos et al., 2014a), and presence/absence of floaters (Castellano et al., 2016). We found that L, CH, and SI all increased with increasing pitch length in both U13 and U14 teams. DC was also larger in games played on a longer pitch, supporting reports by Frencken et al. (2013).

The U13 and U14 teams analyzed in our study occupied approximately 55% of the available playing width in SSG60 (approximately 22 of 40 m), contrasting with an approximate figure of 65% (approximately 45 of 70 m) reported for professional 11-a-side football (Castellano et al., 2013). Coinciding with usage patterns in 11-a-side soccer (Castellano et al., 2013), the teams made greater use of the width of the pitch than its length in all formats except SSG60 in the U13 category. The only similar finding reported by Folgado et al. (2014) in this respect was for a 3v3 SSG played on a 30 * 20 m pitch by U13 players, where the length per width ratio was less than 1.

The effects of modifications to pitch length on inter-team variables (W2, L2, CH2, and S12) were similar to those observed for the intra-team variables. With the exception of W2, which changed only marginally when pitch size was increased, all the variables increased with greater pitch length. On analyzing the distance between the two furthest-apart players on the pitch (L2), we found that only the U14 team playing on the longest pitch (SSG60) used a similar relative pitch length to that used by professional 11-a-side players (39% [23 of 60 m] vs. 37% [39 of 105 m]) (Castellano et al., 2013). For the rest of the SSGs, the relative length was greater in both the U13 group (54%-72%) and the U14 group (39%-69%). When the length of the pitch was doubled from 30 to 60 m, the distance between defences (L2) increased by approximately 34% in the case of U13 players (from 22 to 32 m) but by just ≈13% in the case of U14 players (from 21 to 23).

An interesting finding to emerge from our study is that the increases in pitch length had a different impact on all variables except W in the two age groups. Contrasting with reports by Olthof et al. (2015), use of width was similar in both age categories and varied only minimally between the four SSG formats. Our results also suggest that U13 players were more affected by changes in pitch length than the more experienced U14 players, who displayed more regular behavioral patterns across the formats. As can be seen in Figure 3, the size of the positive effect of increasing pitch length on L, CH, and SI shows greater differences between U13 than

U14 players, suggesting, as in Barnabé et al. (2016), that older players display more stable co-adaptive behaviors in response to changing conditions. For instance, although the effective playing area used by the U14 players (CH) increased with pitch length, the relative playing area (i.e., the percentage used in relation to the full length of the pitch) actually decreased (from 16% in SSG30 to 11% in SSG60). This did not occur, however, in the U13 category, where the relative values were very similar (17% in SSG30 vs. 15% in SSG60). The situation observed for SI was similar, as the relative change was also more pronounced in the U13 group, suggesting again that younger players show more variable collective behavior when exposed to changes in game conditions.

A similar trend was observed for the inter-team interaction variables (L2, CH2, and S12). The increasing positive effect sizes observed also reflect less stable behavior in the younger players across the SSG formats, with relative values of 26% and 24% for SSG30 and SSG60 in the U13 category compared with 27% and 17% in the U14 category. However, when the behavior of the teams was studied by ApEn, i.e., from the perspective of the unpredictability of behavior related to each of the measures (Figure 5), the findings were quite the opposite. In other words, the behavior of the U14 team was more unpredictable than that of the U13 team. These results coincide with previous findings by Silva et al. (2014b), who found that the distance between rival players was more unpredictable in more expert teams. We found a similar tendency in our study for spatial variables. L2 and W2, for instance, were higher for U14 than U13 players in all SSG formats except SSG30, indicating that younger players are more predictable. Although challenging, the quantification of the unpredictability of play associated with different task constraints and age, has promising applications in numerous areas, such as the evaluation of individual and team performances or talent identification and development.

The findings of this study should be interpreted with caution as interacting individual factors (maturity, physical fitness, etc.) and task constraints could result in different co-adaptive behaviors. The interpretability of our findings is also limited by the fact that we studied just one SSG format with four pitch lengths and two teams. More research is needed to gain a deeper understanding of tactical behavior during game situations and to evaluate the potential generalizability of our findings. The application of additional task constraints in more different age groups could improve our understanding of age-dependent emergent behaviors and help in the design of learning tasks designed to improve tactical performance.

In summary, this study has shown that teams naturally change their spatial dispersion (L and W), use of effective playing area (CH), and distances between centroids in response to changes in pitch length. The strategies adopted reveal different co-adaptation patterns according to length and age. Our results also identified meaningful collective behaviors that suggest that changes to pitch size 1) increase in-

tra-team distances and 2) have a smaller effect on older, more experienced players, although 3) these respond to changes in a less predictable way, that is, older players make the teams more adaptable, and thus, more variable, less predictable to new situations.

Conclusion

The message for coaches is that they can vary simple factors such as pitch size to explore the flexibility of collective tactical behavior and identify desirable co-adaptations. Our results also suggest that coaches can extend the length of the playing area to encourage a greater use of space by the team as a whole, although they should bear in mind that such changes have different effects on players of different ages and with different skill levels. One possible consideration is that U13 players might not be prepared to play effectively on pitches with a large area per player (>200 m²/player). Regardless of our small sample size and limited depth of analy-

sis, our preliminary findings should encourage practitioners to use SSGs to stimulate specific co-adaptive behaviors.

The use of specific, yet, effective training tasks is important, as it not only improves individual performance, but will also help teams to collectively learn to adapt their behaviors to resolve increasingly complex problems.

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