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Different pitch areas of small-sided games for improving spatial dispersion, alter internal training load and technical-tactical skills in under-11 soccer players

Diferentes áreas de jogos de campo reduzido para melhorar a dispersão espacial, alterar a carga interna de treinamento e as habilidades técnico-táticas em jogadores de futebol sub-11

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Resumo: Objetivo: O presente estudo investigou se diferentes áreas do campo de jogo reduzido (JCR) alteram a distribuição espacial, a carga interna de treinamento ou as ações tático-técnicas no campo de jogadores de futebol categoria sub-11. Métodos: A amostra foi composta por 18 jogadores masculinos de futebol sub-11, randomizados em 9 grupos de JCR, 3 x 3, que jogaram sem goleiro, em JCRpequeno (12 x 28 m), JCRmédio (18 x 24 m) e JCRgrande (24 x 30 m). Foram avaliados o percentual de ocupação total da área de campo, área de ação por jogador, frequência cardíaca máxima (FCpico) e média (FCmédia), impulso de treinamento de Edward (TRIMP), ações tático-técnicas e desempenho de jogo. Resultados: A porcentagem da área total ocupada ($p < 0,05$) e a área de ação ($p < 0,05$) por jogador foram menores no JCRgrande ($p < 0,05$). Não foram encontradas diferenças nos valores de FCpico e FCMédia entre as diferentes áreas do JCR ($p > 0,05$). O TRIMP no JCRgrande ($p < 0,05$) foi maior do que no JCRpequeno. Mudanças nas dimensões do campo aumentaram o número de duelos, posse de bola, desarmes e recepções no JCRpequeno. Conclusões: Concluímos que o JCRgrande aumentou a distribuição espacial e a carga interna de treinamento dos jogadores, enquanto o JCRpequeno aumentou o número de ações técnicas.

Palavras-chave: Esporte Juvenil; Habilidade motora; Educação Física e Treinamento; Análise e Desempenho em Tarefas; Frequência cardíaca.

Abstract: Objective: The current study investigated whether different small-sided game (SSG) pitch areas alter the spatial distribution, internal training load, or tactical-technical actions on the pitch of under-11 soccer players. Methods: The sample consisted of 18 male under-11 soccer players, randomized into 9 SSG groups, 3 vs. 3, who played without a goalkeeper, on SSGsmall (12 x 28 m), SSGmedium (18 x 24 m), and SSGlarge (24 x 30 m) pitch areas. The percentage of total pitch area occupancy, action area per player, peak (HRpeak) and mean (HRmean) heart rate, Edward's training impulse (TRIMP), tactical-technical actions, and game performance were evaluated. Results: The percentage of the total area occupied ($p < 0.05$) and the action area ($p < 0.05$) per player were lower in SSGlarge ($p < 0.05$). No differences were found in the HRpeak and HRmean values between different SSG areas ($p > 0.05$). The TRIMP in SSGlarge ($p < 0.05$) was higher than in SSGsmall. Changes in pitch dimensions increased the number of duels, ball possession, tackles, and receptions in SSGsmall. Conclusion: We conclude that SSGlarge increased the spatial distribution and internal training load of players, while SSGsmall increased the number of technical actions.

Keywords: Youth Sport; Motor skill; Physical Education and Training; Analysis and Performance in Tasks; Heart rate.

1. INTRODUCTION

Young soccer athletes, under the age of 11 (U11), demonstrate a deficiency in match dynamics compared to the older categories (Palucci Vieira, et al., 2019). U11 players have difficulty orienting themselves and occupying the areas of the pitch, as they have a direct or immature ability to solve the problems of the match, since their attention is focused only on reaching the target, disregarding collective and spatial actions (Folgado, Lemmink, Frencken, & Sampaio, 2014). This behavior results in smaller areas occupied on the pitch, fewer passes, less ball possession, and more passing errors (Folgado, et al., 2014; Palucci Vieira, et al., 2019). Thus, although soccer performance is dependent on various capacities (Radziminski, Szwarc, Padron-Cabo, & Jastrzebski, 2019; Rowat, Fenner, & Unnithan, 2017; Zhou, Hopkins, Mao, Calvo, & Liu, 2019), in younger athletes, the tactical capacity, spatial orientation, and cognitive processes related to decision-making are essential (Rowat, et al., 2017).

Small Sided Game (SSG) training is used as an efficient learning strategy (Davids, Araujo, Correia, & Vilar, 2013; Hammami, Gabbett, Slimani, & Bouhlef, 2018), since players are encouraged to solve problems in a dynamic and complex environment, reproducing match actions (Clemente, Sarmento, Costa, Enes, & Lima, 2019; Davids, et al., 2013). This training method consists of trying to outmatch situations while manipulating the pitch area, objectives, and rules, creating possibilities for spontaneous and dynamic movements. This depends on contextual decisions and influencing behaviors of teammates and opponents, which allow players to acquire experience in self-organization, and to develop efficient skills (Clemente, et al., 2019; Davids, et al., 2013). Furthermore, SSGs are used to train physical capacities, improving cardiorespiratory fitness and skeletal muscle adaptation (Stojanović et al., 2021). SSGs present physiological responses similar to traditional methods, such as high-intensity interval training (HIIT), with similar values of internal load (% HRmax, % HRreserv, lactate threshold, and rate of perceived exertion) (Selmi et al., 2020).

Recently, a study with young soccer players, from U11 to under-17 (U17) categories, demonstrated that the use of SSGs as a training and assessment strategy shows representativeness and specificity and is well correlated to performance on the pitch (Aquino, et al., 2019). When comparing 3 vs. 3 and 6 vs. 6 SSG strategies there is an increase in the number of balls conquered and received, passes, and shots on goal in 3 vs. 3 SSGs (Clemente, et al., 2019), whereas 3 vs. 3 and 4 vs. 4 SSGs did not change the player field occupation (Folgado, et al., 2014). The use of SSGs with different dimensions can change the area of occupation of players from under-13 (U13) to under-19 (U19) categories and promote different technical-tactical adaptations, such as the predictability of moves in the approach to opponents (Olthof, Frencken, & Lemmink, 2018; Silva, et al., 2014). In addition, depending on the size of the area used, the use of SSG strategies can also increase or reduce the number of technical and tactical actions in the match in young and adult athletes (Joo, Hwang-Bo, & Jee, 2016; Olthof, et al., 2018). However, it has not yet been established which changes in SSG dimensions or in players' relative area of action could improve the occupation of the field area, better distributing the players in the attack and defense fields, alter the internal training load, and improve technical-tactical performance in the U11 category.

The present study aimed to investigate whether different SSG pitch areas alter the occupation of the pitch area, internal training load, and technical-tactical actions in the game of U11 players. The study hypotheses were that different SSG formats promote an increase in the internal load, and that larger formats increase the occupation of the athletes and modify the action patterns concerning the number of passes and possession of the ball.

2. METHODS

Participants

Twenty-one youth male soccer players, U11 category, with a mean age of 10 ± 0.7 years, height of 142 ± 7.4 cm, body weight of 37 ± 4 kg, and body fat percentage of $14.3 \pm 5.7\%$ volunteered for the study. The average time of soccer practice was 4 ± 1.26 years. The children were recruited from the youth football

training center (Fut Talentos, Londrina, Brazil), in the city of Londrina, and participated in championships of the Football League of Londrina and the region. All subjects and their legal guardians were informed about the objectives and procedures of the study and signed the Informed Consent Form prior to data sampling. The study was approved by the Research Ethics Committee Involving Human Beings at the State University of Londrina (protocol no. 3.504.038/2019) and all procedures followed the recommendations of the Declaration of Helsinki.

The inclusion criteria were to have been playing soccer for at least 6 months, with regular training twice a week. The children were required to regularly participate in regional championships played in the U11 category in the year 2019. The exclusion criteria were presenting signs and symptoms of upper respiratory tract infections, the use of chronic medication, the use of antibiotics and anti-inflammatory drugs during the study period, or any injury that contraindicated the physical tests. Goalkeepers were excluded from the study. The sample size was estimated based on the HRmax achieved on three different pitch areas of a stop ball SSG protocol described previously by Halouani et al. (Halouani, Chtourou, Dellal, Chaouachi, & Chamari, 2017). To reach a statistical power of 80%, with a p-value < 0.05, and an estimated effect size of 1.25 from differences between large and medium pitch areas, at least eight participants were necessary.

Protocol

This study was a randomized crossover clinical trial. The SSG format used was 3 vs. 3, without a goalkeeper, with the stop ball rule (in which athletes aim to drive and stop the ball under the foot within an area of one meter beyond the end line), and the number of hits on the ball was free (Halouani et al., 2017). The boys were previously familiarized with the SSG pitch and rules, after which they returned three times, seven days apart, to perform the SSG tests (figure 1). The players were submitted to standardized warm-ups before the SSG tests. During each SSG, peak heart rate (HRpeak), mean heart rate (HRmean), and HR intensity zones were recorded to assess internal training load using the training impulse method (TRIMP) proposed by Edwards (Edwards, 1993). The games were filmed for analysis of player dispersion and in-game performance.

Twenty-one U11 players were randomized, through a simple draw, into seven teams (one reserve team to substitute an SSG session if necessary) of three volunteers using the random tool of the Microsoft Excel program (Microsoft, Redmond, USA), to perform three games on different SSG pitch areas. The SSG format and teams were randomized for each SSG session. All teams played the three SSG formats:

- SSGsmall: 12 x 18 m pitch area, 36 m² of player area (PA).
- SSGmedium: 18 x 24 m, 72 m² PA.
- SSGlarge: 24 x 30 m, 120 m² PA.

The SSG matches lasted 13 minutes, divided into three periods of four minutes, with 30-second intervals between periods. The players performed only one SSG format per day, 7 days apart. The players did not receive verbal motivation during the SSGs. The field assistants replaced the ball immediately after the ball left the side and end lines.

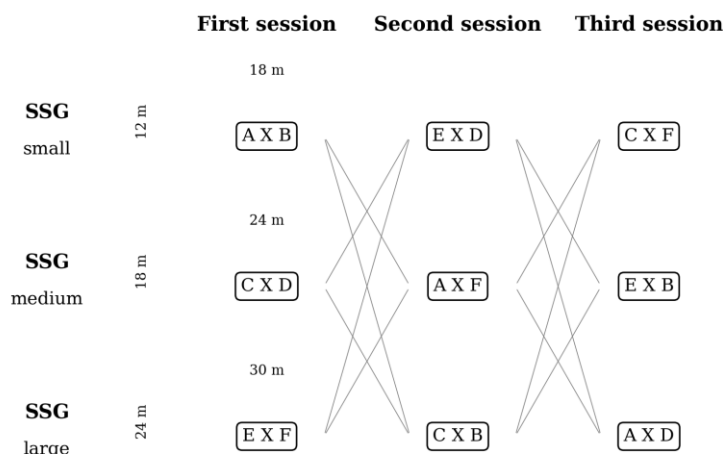


Figure 1. Schedule of allocation of teams to perform the SSG sessions.

Internal training load

The internal training load was assessed using the heart rate (HR) and the training impulse (TRIMP) method proposed by Edwards (Edwards, 1993), in which the value is obtained by multiplying the time spent in each zone by the value of the zone. HRpeak and HRmean were recorded on a portable heart rate monitor (V800, Polar, Kampele, Finland). The time spent in different HR intensity zones was recorded based on the maximum HR expected for the age group (zone 1: 50 to 60%, zone 2: 60 to 70%, zone 3: 70 to 80%, zone 4: 80 to 90%; zone 5: 90 to 100%) (Mendez-Villanueva, Buchheit, Simpson, & Bourdon, 2013).

Action zone analysis

The area of player action was evaluated to quantify the movement and occupation of the pitch area during the game, according to the model proposed by Gréhaigne et al. (Gréhaigne, Bouthier, & David, 1997). The field was divided into quadrants of 36 m², and the presence of at least one player in the quadrant was computed to calculate the percentage area occupied (%occupation) and total area occupied (m²) by the teams. The area of action of the players was calculated by the sum of the area occupied (m²) divided by the number of players on the field (players/m²).

The SSGs were filmed with a digital camera (Hero 7 Silver, GoPro, San Mateo, USA) positioned 10 meters from the sideline of the field. For video analysis, the field was divided into equal quadrants (6 m x 6 m) and the positioning of the player was recorded at each time interval of 5 seconds. All analyses were performed by three trained and independent evaluators. The intra-evaluation and inter-evaluator kappa agreement coefficients were > 0.9.

Performance analysis

The technical and tactical actions evaluated were the number of duels, passes, percentage of successful passes, number of balls lost, ball possessions, blocks, interceptions, tackles, dribbles, and receptions (Dellal, et al., 2012; Palucci Vieira, et al., 2019; Selmi, Marzouki, Ouergui, BenKhalifa, & Bouassida, 2018).

Game performance was assessed using the Team Sports Assessment Procedure proposed by Gréhaigne and collaborators (Gréhaigne, et al., 1997), and applied to SSG analysis as described by Brandes and Elvers (Brandes & Elvers, 2017). The number of balls taken (BT), balls received (BR), balls lost (BL), neutral balls (BN), passes (PA), and successful shots on goal (SG) were evaluated. From these data, the game volume (BT + BR), effectiveness index (efficiency) $((PA + SG) / (10 + BL))$, and total game performance $((\text{game volume} / 2) + (\text{efficiency index} \times 10))$ were calculated (Brandes & Elvers, 2017). All analyses were performed by three trained and independent evaluators. The kappa agreement coefficient between evaluations and between evaluators was > 0.88.

Statistical analysis

The normal distribution of data was assessed using the Shapiro-Wilk test. Continuous data are presented as mean and standard deviation (parametric data) or medians and quartiles from 25 to 75% (non-parametric data). Categorical data are presented as absolute and relative frequencies. The differences in the percentage of time in different zones of HR in different SSG areas, Edward's TRIMP, area occupation, and players' action area were determined by the Kruskal-Wallis test with Dunn's post hoc. Differences in the number of technical and tactical actions and game performance were determined with the ANOVA test with Tukey's post hoc (parametric distribution), or the Kruskal-Wallis test with Dunn's post hoc (non-parametric distribution). Differences between SSG areas were considered significant if $p < 0.05$. The total numbers of technical and tactical actions of each team in different SSG formats were added and the size of the effect of the change in pitch areas was assessed by Cohen's d coefficient (1992).

3. RESULTS

No significant differences were detected between the mean values of HR_{peak} (figure 2a) and HR_{mean} (figure 2b) in the three SSG pitch areas. However, the internal training load (TRIMPEDWARDS) was significantly higher in the SSG_{large} format compared to the SSG_{small} format matches (Figure 2c).

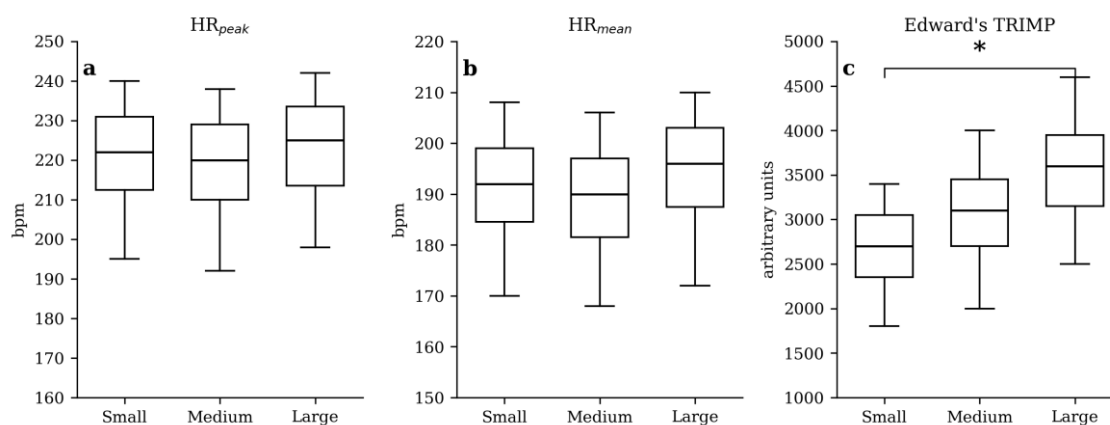


Figure 2. HR_{peak} (a), HR_{mean} (b) in beats per minute (bpm), and TRIMPEDWARDS (c) of U11 players on SSG_{large}, SSG_{medium}, and SSG_{small} pitch areas. The horizontal line represents the median, the box represents the quartiles from 25 to 75%, and the vertical line represents the maximum and minimum values. * $p < 0.05$, Dunn's test.

The percentage of the total pitch area occupied by the players was large in SSG_{small} compared to SSG_{medium} and SSG_{large} (figure 3a). Despite occupying a large percentage of pitch area in SSG_{small}, players increased the total area occupied when pitch areas increased (Figure 3b). The players also presented a smaller action area in SSG_{small} (figure 3c).

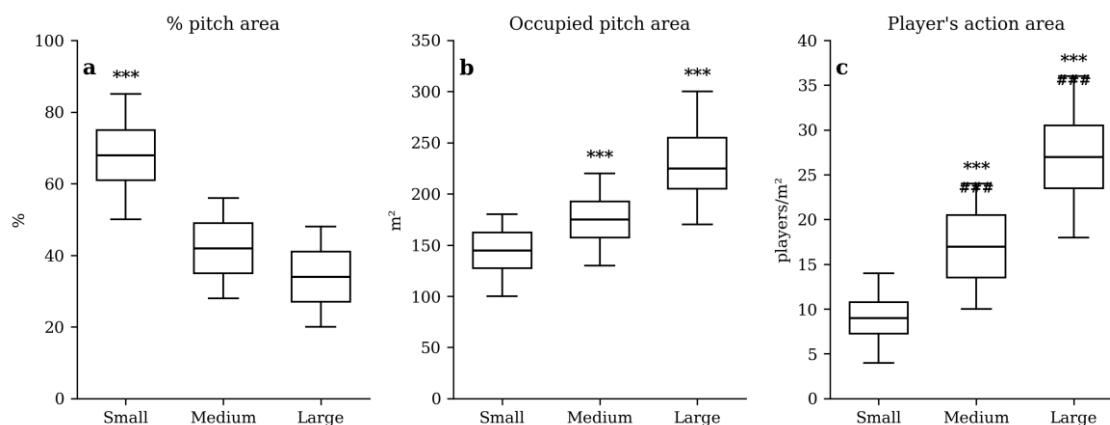


Figure 3. Percentage of the total pitch area occupied (a), occupied area (b), and player's action area (c) in the SSGs. The horizontal line represents the median, the box represents the quartiles from 25 to 75%, and the vertical line represents the maximum and minimum values. *** $p < 0.005$ in comparison to SSG_{large}, ### $p < 0.005$ in comparison to SSG_{medium}, Dunn's test.

The technical and tactical actions showed no significant differences between the SSG pitch areas, except for the neutral balls (Table 1). A large effect size was found in the number of duels, passes, lost balls, tackles, neutral balls, and score passes, and a moderate effect size for ball possession, reception, and score between the small and large SSG areas. For the SSGsmall and SSGmedium, the number of duels, tackles, receptions, and neutral balls obtained a large effect size, and passes, percentage of successful passes, lost balls, score passes, and score obtained a moderate effect size. Only the percentage of correct passes presented a large effect size between the SSGmedium and SSGlarge, while lost balls, ball possession, dribbling, and neutral balls had a medium effect size for these formats (Table 2).

Table 1. Technical-tactical actions in the three small-sided game pitch areas.

	SSGsmall	SSGmedium	SSGlarge
Duels	32.67 ± 9.26	25.89 ± 4.48	25.56 ± 2.18
Passes	27.11 ± 5.44	23.89 ± 4.56	21.78 ± 5.21
%Successful passes	81.28 ± 9.60	77.09 ± 4.13	84.73 ± 8.76
Lost Ball	13.33 ± 3.7	11.56 ± 2.87	9.88 ± 2.97
Ball Possessions	15.56 ± 4.39	14.89 ± 2.36	13.22 ± 3.07
Blocks	2.44 ± 1.42	2.11 ± 1.26	1.88 ± 1.53
Interceptions	1.66 ± 1.8	2.00 ± 1.22	2.33 ± 2.39
Tackles	21.00 ± 6.89	14.11 ± 3.72	14.78 ± 4.35
Dribbles	7.55 ± 3.94	7.22 ± 1.48	8.66 ± 2.44
Receptions	22.11 ± 4.13	18.33 ± 3.53	19.22 ± 4.02
Conquered Balls	4.88 ± 2.61	5.44 ± 2.5	4.88 ± 2.08
Neutral Balls	22.44 ± 4.82	18.11 ± 5.08	15.56 ± 3.2***
Score Passes#	1.66 ± 0.7	2.55 ± 2.35	2.55 ± 1.01
Score#	2.22 ± 1.92	3.33 ± 1.22	3.33 ± 1.87

Adapted because there was no goal kick in the Stop Ball model, the goal was replaced by the score. *** $p < 0.05$ compared to SSGsmall.

Table 2. Cohen's Effect Size of Technical-tactical actions in different SSGs.

	SSGsmall X SSGmedium	SSGsmall X SSGlarge	SSGmedium X SSGlarge
Duels	0.93 (large)	1.05 (large)	0.09 (trivial)
Passes	0.64 (medium)	1.00 (large)	0.43 (small)
%Successful passes	0.56 (medium)	0.37 (small)	1.11 (large)
Lost Balls	0.53 (medium)	1.02 (large)	0.57 (medium)
Ball Possessions	0.19 (trivial)	0.61 (medium)	0.6 (medium)
Blocks	0.24 (small)	0.37 (small)	0.16 (trivial)
Interceptions	0.22 (small)	0.31 (small)	0.17 (trivial)
Tackles	1.24 (large)	1.07 (large)	0.16 (trivial)
Dribbles	0.11 (trivial)	0.33 (small)	0.71 (medium)

Receptions	0.98 (large)	0.7 (medium)	0.23 (small)
Conquered Balls	0.21 (small)	0 (trivial)	0.24 (small)
Neutral Balls	0.87 (large)	1.68 (large)	0.6 (medium)
Score Passes#	0.51 (medium)	1.02 (large)	0 (trivial)
Score#	0.69 (medium)	0.58 (medium)	0 (trivial)

Adapted because there was no goal kick in the Stop Ball model, the goal was replaced by the score.

The performance analysis showed the best results for the SSGlarge format (Table 3).

Table 3. Performance in different SSGs.

	SSGsmall	SSGmedium	SSGlarge
Game Volume	13.49	11.88	12.05
Efficacy Index	0.11	0.18	0.19
Total Performance	7.84	7.74	7.92

4. DISCUSSION

The results of the study showed that the different SSG areas have some impact on internal training load, and the larger pitch area (SSGlarge) increased the dispersion of players on the field. On the other hand, small areas (SSGsmall) increased the number of technical-tactical actions, especially defensive (duels, tackles, and lost balls) and actions related to a combination of passes. Thus, SSGlarge areas may be used to improve spatial dispersion and physical aspects, whereas SSGsmall areas may be used to develop technical-tactical skills in U11 soccer players.

Although changes in the size of the pitch did not promote differences in the physiological responses of HRpeak and HRmean, the internal training load was greater in the SSGlarge. This suggests that a large SSG pitch area could be an interesting alternative in the physical training of U11 players. Similar findings regarding HR variables were observed by other authors, in the under-13 and under-14 categories (Lemes, et al., 2019). However, in studies on players in the under-15 and under-17 categories, the SSGs with a larger area (stop ball or goalkeeper formats) also increased the internal training load, including an increase in HRpeak and HRmean during the match (Casamichana & Castellano, 2010; Halouani, et al., 2017). Differences between pitch sizes, rules, categories, and the number of players could contribute to the divergences in results observed in the literature (Aguiar, Botelho, Lago, Macas, & Sampaio, 2012; Coutinho, et al., 2019; Joo, et al., 2016; Lemes, et al., 2019; Martone, et al., 2017).

Alteration in the SSG pitch area seems to influence the player's spatial distribution on the field in U11 players. Young players aim to solve playing moves more quickly, with more individualistic behavior than players of higher age categories (Folgado, et al., 2014). Altering the pitch area can promote changes in the area occupied by each player and in the number of technical-tactical actions performed by youth soccer athletes (U15 and U17) (Casamichana & Castellano, 2010), however, athletes in these age groups have a better ability to occupy the field area and greater technical-tactical skills than the U11 category (Palucci Vieira, et al., 2019). Thus, it was not established whether the strategy of changing the field area could also change the players' pitch occupation area and the number of technical and tactical actions in U11 football players. The results of the present study suggest that the dimensions of the playing pitch in the formats observed were able to change the spatial distribution of U11 players, or could be used to improve technical-tactical skills. Choosing different dimensions of pitch area should depend on the objectives of coaches and team staff, as well as the training periodization schedule.

The technical and tactical actions in SSGs are influenced by the size of the pitch. On smaller pitch areas, adult and youth athletes (U13) travel shorter distances and execute more passes and kicks, but spend less time in ball possession and make more wrong passes (Aslan, 2013; Hodgson, Akenhead, & Thomas, 2014; Joo, et al., 2016). In the present study, changes in the dimensions of the pitch were not able to significantly modify the number of technical actions performed in a play, except for the number of neutral balls between the SSGlarge and SSGsmall. In a review by Aguiar (2012) the authors noted that changing the size of the pitch is not able to modify the frequency of most technical actions. However, analyzing the technical actions between the different SSGs, a high effect size was observed, with a greater number of duels, lost balls, and tackles in the small format, in relation to the SSGlarge. These results suggest that the smaller area of the pitch increases the chances of confrontations that result in the loss of the ball.

5. CONCLUSION

We conclude that the SSGlarge pitch area, in the format 3 vs 3, stop-ball, with free touches, causes a significant increase in the internal training load, increasing the total area occupied by U11 players on the field. On the other hand, the small pitch format increased the number of technical actions in the SSG. Considering that the SSGlarge increased the internal load and dispersion of the athletes in the field, we suggest that this format could be better used in pre-season moments, however, the SSGsmall increased the number of technical actions performed, which may be of interest during the season.

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8. INSTITUTIONAL REVIEW BOARD STATEMENT

Comitê de Ética em Pesquisa Envolvendo Seres Humanos da Universidade Estadual de Londrina (protocolo nº 3.504.038/2019).

9. AUTHOR CONTRIBUTIONS (CREDIT)

T.R.A.: Conceituação, Validação, Metodologia, Investigação, Análise formal, Curadoria de dados, Redação – texto original

M.G.W.: Investigação, Análise formal, Curadoria de dados

E.C.F.T.: Investigação, Análise formal, Curadoria de dados

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V.F.M.: Conceituação, Validação, Metodologia, Investigação, Recursos, Supervisão, Análise formal, Curadoria de dados, Redação – texto original

S.P.R.: Conceituação, Validação, Metodologia, Recursos, Investigação, Análise formal, Curadoria de dados, Redação – texto original

10. CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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