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The effects of game types on intensity of small-sided games among pre-adolescent youth football players

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ABSTRACT: The aim of this study was to examine the effects of variations in pitch dimensions on pre-adolescent youth soccer players' physiological responses during two different types of small-sided games (SSG). Sixteen young soccer players (age: 13.2 ± 0.6 years; body mass: 52.5 ± 7 kg; height: 163.4 ± 6 cm) participated in this study. They performed 4 vs. 4 stop-ball SSG (SB-SSG) vs. small-goals SSG (SG-SSG) with 4×4 min and 2 min of passive recovery in between, using 3 different pitch sizes (small: 10×15, medium: 15×20, and large: 20×25 m). Heart rate (HR), lactate concentration ($[La^-]$), and rating of perceived exertion (RPE) were measured during each session. The results show that SB-SSG induced higher HR responses than SG-SSG for the 3 pitch sizes: for HR (167.2±3.0 vs. 164.5±3.0, 172.3±2.9 vs. 169.2±3.1, and 175.4±3.1 vs. 171.1±2.7 bpm; $P<0.05$, for small, medium, and large, respectively) and $[La^-]$ (7.1±1.0 vs. 6.5±1.04, 7.3±1.0 vs. 6.8±1.2, and 7.8±0.9 vs. 7.1±0.8 $mmol \cdot l^{-1}$; $P<0.05$ on small, medium, and large pitches, respectively), whereas RPE scores were significantly higher during SB-SSG compared to SG-SSG (6.2±1.0 vs. 5.8±0.9; $P<0.05$, respectively) on the small pitch. In the present study higher physiological responses were observed in SSG in pre-adolescent young soccer players when using the stop-ball conditions in comparison with the small-goal rule for all pitch sizes – small, medium, and large. Stop-ball conditions in comparison with the small-goal rule for all pitch sizes – small, medium, and large.

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INTRODUCTION

Small-sided games (SSG) are thought to be suitable for developing the particular physical characteristics that players require under conditions of pressure and fatigue [1, 2]. This is because these types of games include high-intensity activities (short sprint, tackling, and sliding) involving various movement types and patterns similar to those used in soccer matches [3], reproducing competition activities [e.g.4 , 5]. The majority of previous studies concerning SSG have focused on adult players [6, 4, 7, 8, 9, 10 ,11], and a limited number of studies have assessed the impact of SSG on youth players [12, 13, 14, 15]. Although these studies have been conducted with adult players, high-intensity training has also been shown to induce improvements in the aerobic fitness of young individuals [16]. Therefore, young players might potentially benefit from SSG-based training. Physiologically, youth soccer players present lower values of maximal oxygen uptake (VO_{2max}) than adults [17]. Moreover, Helgerud et al. [18] reported that the technical activity and total sprinted distance during the match play of youth soccer players improved with the increase in VO_{2max}. Also, different SSG conditions may show different responses and, therefore, they may be used for a different purpose as part of soccer training. This is important for youth soccer, where the aim of training is not always to enhance team strategy but also to allow young players to enhance their technical skills and to develop team cohesion [19].

Several factors are thought to influence the physiological stress associated with SSG and, hence, the impact on this form of training's ability to be a useful means for physical training [20]: dimensions of the pitch [21, 7], number of players [22, 23], coach encouragement [9], training regimen (i.e., continuous and intermittent modality) [24, 25], game duration [26] and rule modifications [27, 4, 28, 29]. Several studies have investigated the effect of changing pitch dimensions on physiological responses [7, 9, 30]. However, the results are somewhat conflicting. Rampinini et al. [9] found that for the same number of players, the intensity was higher during SSG played on a large pitch than on medium-sized and small ones. In contrast, Kelly and Drust, [30] found a decrease in HR (91 vs. 90 vs. 89 %) with the increase of the pitch area in soccer SSG (i.e., 30×20, 40×30, and 50×40 m respectively) when the number of players involved in the games was held constant (5 vs. 5). These authors then suggested that the pitch dimensions were not a primary factor affecting the HR responses to SSG, unless they are combined with other important factors such as the number of players. Another possible factor influencing the SSG outcome could also be the games' rules. In that regard, to the best of the authors' knowledge, only the study of Halouani et al. [29] has compared SSG physiological responses with stop-ball (SB-SSG) and small-goals (SG-SSG) rules on young players. However, these authors only used one pitch size (20×15 m), reporting higher HR and [La] responses during SB-SSG compared to SG-SSG. The reported RPE scores were not significantly different between conditions. Moreover, the influence of changing the playing area on the intensity of SSG has previously been reported [31, 32].

Therefore, the purpose of the present study was to examine the influence of 3 pitch sizes (i.e., small, medium, and large) during stop ball (SB-SSG) and small goal (SG-SSG) rules on the physiological responses (i.e., HR, La, and RPE) of young soccer players.

MATERIALS AND METHODS

Subjects. Sixteen young soccer players (age: 13.2 ± 0.6 years; body mass: 52.5 ± 7 kg; height: 163.4 ± 6 cm) from the same first league team were recruited to participate in the study. Maturity was assessed by using a self-administered Tanner scale (maturity stages from P1 to P6; where P1 = pre-puberty, P2–P3–P4 = puberty, and P5–P6 = post-puberty) that has been shown to be a valid and reliable method for assessing sexual maturity in elite adolescent athletes [33]. The number of players in each maturation stage was 2 for P6, 7 for P5, 4 for P4, and 3 for P3. All of the players had at least 3 years' experience of soccer training and play in an amateur league. Participants and parents were informed about the study protocol, requirements, benefits, and risks before giving written informed consent.

The study protocol was approved by the University Ethics Committee and complied with the principles of the Declaration of Helsinki.

Experimental procedure

To examine the influence of the pitch area variation during SB-SSG and SG-SSG on physiological responses, a constant number of players (i.e., 4 vs. 4) and 3 pitch sizes (i.e., small: 10×15 (150 m^2), medium: 15×20 (300 m^2), and large: 20×25 m (500 m^2)) were employed. The pitch ratio per player (pitch area divided by the number of players) was 1:19 m^2, 1:37.5 m^2 and 1:62.5 m^2 respectively for the small, medium and large pitch areas. The players performed 4×4 min SSG with 2 min of passive recovery in between. The players were familiarized with both types of SSG and the procedures to be used during the weeks prior to the experiment. In a randomized order, the players performed 6 training sessions: SB-SSG and SG-SSG in 3 pitch areas. During the SB-SSG rule games, the subjects were instructed to stop the ball in a 1-m wide zone behind the end line of the playing pitch (Figure 1). Stopping the ball means finding a way of entering the "goal zone" with the ball and stopping the ball under the sole of one foot. A ball transiting into the zone was not sufficient to obtain a goal. The SB-SSG is a game that is based on the stop ball. Therefore, our game cannot be classified as directional or transitional types. However, during the SG-SSG, the subjects were instructed to score a goal in small goals placed at the centre of the end line of the pitches. The goal dimensions were 1 m width and 0.5 m height (Figure 2). The number of ball contacts allowed was free. During the SB-SSG and the SG-SSG, all participants were asked to defend and attack and no goalkeepers were used. Moreover, during all the SSG, coaches offered encouragement to the participants in order to ensure high motivation [9]. In addition, eight balls were distributed around the edge of the pitch in order to maximize the effective playing time. Hence no time was lost in catching a ball out of the games. Each session began with an ~15-min standard warm-up (i.e., running and dynamic stretching followed by ball specific

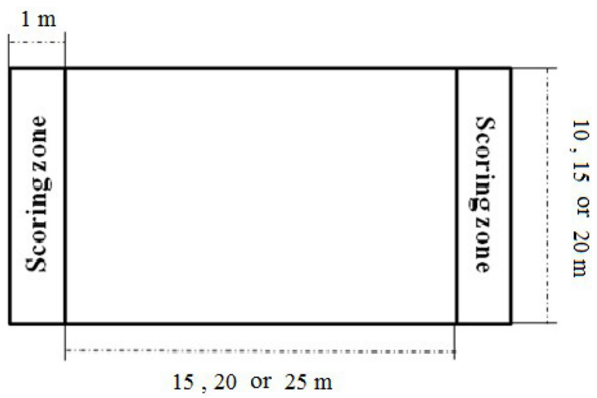

FIG. 1. Stop-ball small-sided games for small, medium, and large size pitches [29].

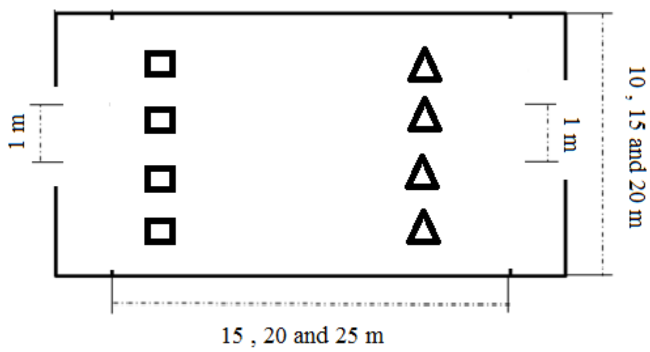

FIG. 2. Small-goals small-sided games for small, medium, and large sizes pitches.

warm-up). Heart rate (HR) was recorded every 5 s during each training session (Polar S-810; Polar-Electro, Kempele, Finland). RPE scores (10-point scale [34]) were recorded immediately (within one minute) after the end of exercise (4×4 SSG). Capillary blood samples were taken from an earlobe within a minute of the end of the last bout of the SSG [35] and immediately analysed for lactate using a portable amperometric microvolume lactate analyser (LactatePro, Arkray, Japan). All SSG were performed at the same time of day (from 16 to 18 h) in order to limit the effects of the circadian variations on the measured parameters [36].

Statistical analysis

Data were analysed using a two-way analysis of variance (ANOVA) [2 (situations: SG- vs. SB-SSG) × 3 (pitch size: small, medium, and large)]. All statistical analyses were performed using the software package STATISTICA (StatSoft, Maisons-Alfort, France) and significance was set at $P < 0.05$.

RESULTS

Heart rate. HR values recorded during the SB-SSG were significantly higher in comparison to those registered during the SG-SSG (Figure 3), with higher intersubject coefficients of variation (CV) during SG-SSG in the small and the medium size compared to the large pitch (Table 1).

Moreover, HR values were significantly higher in the SB-SSG in the large pitch in comparison with the small and the medium pitches (Figure 3).

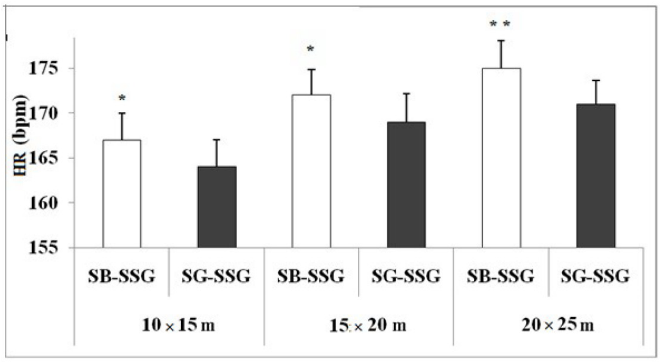

FIG. 3. Heart rate (HR) values recorded during stop-ball (SB-SSG) and small-goal small-sided games (SG-SSG) in the small, medium, and large size pitches; * - indicates significant difference between SB-SSG and SG-SSG at p-value < 0.05; ** - p<0.01.

TABLE 1. Inter-subject coefficient of variation (CV) of the HR values during SB-SSG and SG-SSG in the 3 pitch sizes.

Dimension (m)	10×15	15×20	20×25
SB-SSG (CV %)	1.78	1.68	1.75*
SG-SSG (CV %)	1.85*	1.85*	1.55

Note: SB-SSG - stop-ball small-sided games; SG-SSG - small-goals small-sided games; * - indicates significant difference between SB-SSG and SG-SSG at p-value < 0.05.

Rating of perceived exertion

The results revealed that RPE scores were significantly higher only in the small pitch for SB-SSG (Figure 4). However, there was no significant difference between SB-SSG and SG-SSG for the medium and the large pitches. Moreover, the RPE scores were significantly higher during the large-pitch SB-SSG, in comparison with the small and the medium pitches.

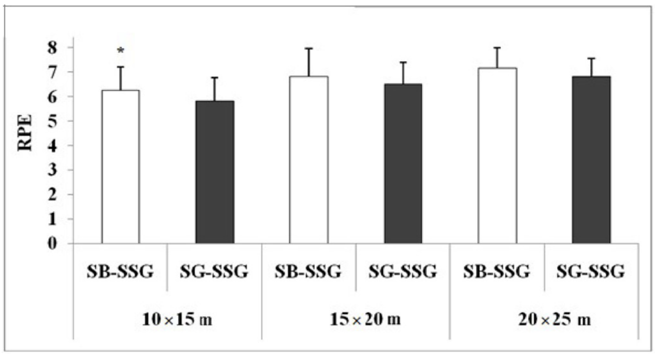

FIG. 4. RPE scores during stop-ball (SB-SSG) and small-goal small-sided games (SG-SSG) in the small, medium, and large size pitches; * - indicates significant difference between SB-SSG and SG-SSG at p-value < 0.05.

Lactate concentrations

The results for the games with the 3 pitch sizes showed that [La-] values were significantly higher in the SB-SSG compared to the SG-SSG (Figure 5), while [La-] concentrations were significantly higher for the 20 × 25 m dimensions in comparison with the 10 × 15 m and the 15 × 20 m dimensions (Figure 5).

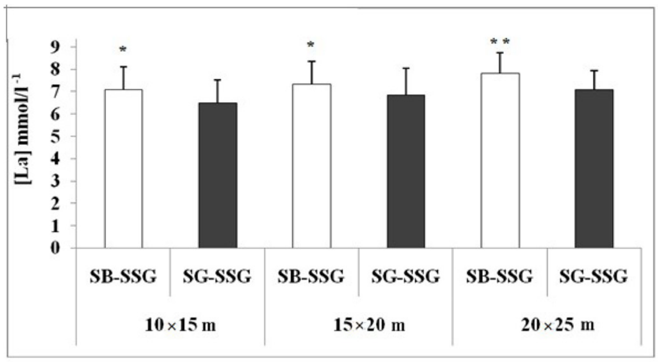

FIG. 5. [La-] values during stop-ball (SB-SSG) and small-goal small-sided games (SG-SSG) in the small, medium, and large size pitches; * - indicates significant difference between SB-SSG and SG-SSG at p-value < 0.05; ** - p<0.01.

DISCUSSION

The purpose of the present study was to examine the physiological responses to variation in pitch dimensions (i.e., small: 10 × 15 m, medium: 15 × 20 m, and large: 20 × 25 m) during stop-ball (SB-SSG) and small-goal (SG-SSG) games in pre-adolescent soccer players. The main findings demonstrate that SB-SSG induced higher HR and [La-] responses than SG-SSG for the 3 pitch sizes, while RPE scores were significantly higher in SB-SSG compared to SG-SSG only in the smaller pitch (i.e., 10 × 15 m). Moreover, the present study also showed that a greater physiological response to SSG was observed during SB-SSG with the larger pitch size.

The findings of the present study showed that HR and [La-] were significantly higher in SB-SSG than SG-SSG for the 3 pitch sizes. Moreover, according to HR_{max} SB-SSG induced higher HR responses compared to SG-SSG (80.6 vs. 79.2; 83 vs. 81.6 and 84.5 vs. 82.6%). In this context, only the study of Halouani et al. [29] has investigated the effects of SB-SSG and SG-SSG on the physiological responses to 3 vs. 3 SSG in young soccer players. In this study only one pitch size was used (i.e., 15 × 20 m) and, in agreement with the present study findings, the authors reported that HR and [La-] induced higher intensities in SB-SSG than SG-SSG. Likewise, as suggested by Halouani et al. [29], the present study confirms the higher SSG intensities observed during the SB-SSG than the SG-SSG, which could be explained by: (i) the larger area that the defensive and the attacking players must cover in the SB-SSG condition and/or (ii) the motivation factor (players are motivated by this new form of scoring [29]), and possibly the technical abilities. Moreover, the inclusion of goals and shots at goal in youth players can modify the physiological behaviour of the players. These shots indeed increase the frequency of lost balls in the game, so a new ball might be provided in the arena. If ever the number of balls available is not high enough for continuous immediate replacement, this might be an impacting factor. All of that can decrease the intensity of the SG-SSG.

In this context, Dellal et al. [37] concluded that the high intensity actions in 2 vs. 2 and 3 vs. 3 SSG with youth players may be linked to the greater technical difficulty combined with the possibly lower duration to perform particular technical actions. Youth soccer players need to develop their physical performance, but also their perceptive and technical abilities. The difference between the present study findings and those of Halouani et al. [29] is that in the present study the higher HR and [La-] values observed in SB-SSG were recorded during the 3 pitch dimensions. However, in the study of Halouani et al. [29] this difference was observed only for 15×20m. This reflects the effectiveness of SB-SSG for soccer training whatever the pitch dimensions. Because there is no study that has analysed the effects of variation in pitch dimensions on game rules with a constant number of players on very young players, we speculate that this higher intensity in the 3 pitch sizes for SB-SSG is due to the technical rules that are related to a team's chance of scoring (stopping the ball in the zone behind the end line), which may influence the player's motivation to increase and maintain exercise intensity and, therefore, increase the player's physiological response to SSG. In this context, Dellal et al. [13] reported a higher exercise intensity ($\%HR_{res}$) when the number of ball touches authorized was reduced (one touch, 83.6 ± 3.3%; two touches, 80.8 ± 4.1% of HR_{max}) during 4 vs. 4 SSG. In the present study, although the number of ball touches was not measured, we subjectively observed that during SB-SSG the defenders frequently closed down the opponents, resulting in fewer ball touches. As a result, attackers probably performed quicker movements with more displacement to receive passes, potentially leading to a higher physiological load and eventually greater exercise intensity.

Concerning RPE scores, the results showed that RPE was significantly higher in SB-SSG than SG-SSG only in the smaller pitch size (i.e., 10 × 15 m). Previous studies suggested that distractions during exercise can lower RPE scores even when the intensity (e.g. HR, and % $VO2_{max}$) were the same [38, 39]. When a visual distractor (i.e., small goal) was used in SSG, the attention of players may have been distracted during the games.. This distraction could explain the higher sessions-RPE observed only in the smaller pitch size (i.e., 10 × 15 m) during ~~in~~ SB-SSG [38, 39]. This unlikely explanation should be experimented in the future. Hill-Hass et al. [40] concluded that in SSG there were changes in physiological and time-motion responses but not in perceptual responses (i.e., RPE) when rule changes are employed.

The results of the present study demonstrate that higher intensity was found during the larger pitch dimensions (i.e., 20 × 25 m). Also, the results show that SB-SSG in the large pitch produced 84.5% HR_{max}. These results confirm that the increase in pitch dimensions with a constant number of players (4 vs. 4) may increase the physiological demands of SB-SSG (HR, [La-] and RPE). Indeed, in line with other studies [41, 21, 42, 9], we found that the increase in pitch dimensions with a constant number of players led to an increase in physiological responses to SSG (i.e., HR, La, RPE).

Owen et al. [41] showed that, as the pitch size became larger, with the number of players remaining constant, HR generally increased. Moreover, Williams and Owen [21] found an increase in HR with the increase of the pitch area during 3 vs. 3 SSG (i.e., 164 vs. 166 vs. 171 bpm for 15 × 20 m, 20 × 25 m and 25 × 30 m, respectively). Similarly, Casamichana and Castellano [42] demonstrated that increasing pitch dimensions allows increases in physiological responses (HR, RPE) during 5 vs. 5 SSG with 3 pitch sizes: for HR_{max} (93 vs. 94.6 vs. 94.6 % during 23 × 32 m, 50 × 35 m, and 88 × 62 m respectively), for RPE (5.7 vs. 6.7 vs. 6.7 during 23 × 32 m, 50 × 35 m, and 88 × 62 m respectively). Also, Rampinini et al. [9] found that SSG played on a larger pitch were more intense than the same drills played on smaller pitches: for 3 vs. 3, HR_{max} (i.e., 89.5 vs. 90.5 vs. 90.9% during 20×12 m, 25×15 m and 30×18 m, respectively), [La-] (i.e., 6.0 vs. 6.3 vs. 6.5 $mmol \cdot l^{-1}$ respectively) and RPE (8.1 vs. 8.4 vs. 8.5, respectively).

SSG are very beneficial for players, particularly during learning stages of grassroots and youth football players [43]. Also they are a useful tool allowing the identification of talent in youth soccer players [44].

Physiologically, youth soccer players present lower values of VO_{2max} than adults [17]. Game intensity is lower in youth soccer players, with a total distance covered of around 9 km for the U18 category and 6.2 km for the U12 category, lower HR responses (93% of HR_{max} in elite adult players vs. 82% of HR_{max} in U18) and a lower [La-] concentration (10 $mmol \cdot l^{-1}$ in elite adult players vs.

5 mmol·l^{-1} in the U12 category) [19]. Therefore, young players should not be considered as little adults [45]. Thus, coaches have to pay attention to the fact that youth soccer players do not present the same technical ability as adult or elite players. The youth presented greater anthropometric and physiological differences according to their positions than those observed in adult players [46]. For this reason, youth soccer players need to develop their physical performance (VO_{2max} and ability in repeated sprints), technical, and tactical abilities according to their playing positions. Also, youth soccer training should prioritize the development of basic motor abilities, improvement of soccer skills and increase of the fitness level of young players [47, 48].

Concerning the small number of players participating in this study (n=16), most studies in SSG have used a small number of subjects participating in their research, and some of them have used the same number of our sample size [1, 32]. Moreover, in our study (SB-SSG vs. SG-SSG) 16 players fulfilled the inclusion criteria for participating in the research.

Therefore, the results of this study demonstrate that with changing game rules (SB-SSG and SG-SSG), and altering pitch dimensions at the same time, we can manipulate the SSG intensities in youth soccer players.

This study has some limitations. The lack of the use of GPS does not allow us to provide more accurate data on the players' motion. Further studies in SB-SSG and SG-SSG might investigate some comparisons made using GPS.

CONCLUSIONS

The present study demonstrated that stop-ball SSG induced higher intensities than small-goal SSG in the 3 pitch sizes tested. Thus, SB-SSG could be an effective way to increase intensity in SSG whatever the pitch dimensions. Moreover, the findings demonstrated that higher exercise intensities (HR, La and RPE) were observed for the larger size (i.e., 20 × 25 m) than the two other sizes (10 × 15 m and 15 × 20 m). In conclusion, the pitch dimension factor should be taken into account when designing SB-SSG, because it affects the physiological responses of players.

Conflict of interests: the authors declared no conflict of interests regarding the publication of this manuscript.

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