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Soccer small-sided games in young players: rule modification to induce higher physiological responses

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ABSTRACT: The aim of this study was to identify the physiological responses of 3 forms of players' numbers during two different games rules of small-sided games (SSG: stop-ball *vs.* small-goals rules). Eighteen youth amateur soccer players (age 13.5±0.7 years; height 168.9±6.1cm; body mass 63.1±7.7 kg) participated in this study and performed 3 SSGs with varying players' number (2*vs.*2; 3*vs.*3 and 4*vs.*4): stop-ball SSG (SB-SSG) *vs.* small-goals SSG (SG-SSG) in a randomized and counter-balanced order on a constant pitch dimension (20×25m). The players performed 4×4 min SSG with 2-min of passive recovery in-between. Heart rate (HR), (expressed in bpm and % HRmax), lactate ([La^-]), and rating of perceived exertion (RPE) were collected during each session. SB-SSG induced the higher HR values in comparison with the SG-SSG for the 3 game formats (2*vs.*2; 3*vs.*3 and 4*vs.*4). Also, compared with SG-SSG, SB-SSG induced the higher HR values during 2*vs.*2 compared with 4*vs.*4 games rules (178 *vs.* 174 and 175 *vs.* 171 bpm, respectively). However, the SB-SSG was more intense compared with SG-SSG in the 2 *vs.* 2 game rule compared with the two others (3 *vs.*3 and 4 *vs.* 4) for [La^-] and RPE (7.58 *vs.* 7; 7.25 *vs.* 6.75 and 6.5 *vs.* 6.16 mmol·L^{-1}, and 7.75 *vs.* 7.33; 7.41 *vs.* 7.08 and 7.16 *vs.* 6.83, respectively). Therefore, the use of 2 *vs.* 2 and 3 *vs.* 3 SSG with SB-SSG seems to represent an alternative to coaches to increase cardiovascular and metabolic demands in youth soccer players.

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INTRODUCTION

There is evidence that small-sided games (SSGs) are an effective training modality used for soccer-specific aerobic endurance. The strategy of using the ball and playing situations provides sport-specific activities and allows the concomitant training of technical and tactical skills where players are kept motivated [1]. In junior or youth soccer the competitive format needs to be adapted to the characteristics of those involved, and consequently the rules are often modified to suit the physical development of children and youngsters [2]. These adaptations make it easier for them to take part [3] by increasing their experience in the game. In this context, some studies have examined how the structure of training can be adapted by changing the pitch size [4, 5, 6], the number of players [7, 8, 9, 10], continuous and intermittent modality [11, 12], goalkeepers' participation [4, 13,14] and rules modifications [15, 16, 17, 18, 19]. To illustrate this, there are some differences between studies about the inclusion of goalkeepers and scoring without goalkeepers [13, 14]. Knowing that the task constraints manipulation could affect the physiological responses and, therefore, the potential beneficial effect for performance improvement, we have including a new form of scoring (with stop – ball and small – goals).

Although many of 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 [20]. However, the physiological response observed in SSGs change because of its formats. The number of players is a variable that is often modified not only in competitive settings but also during training drills, where it affects the task intensity [21], which increases when player number per team is reduced. Various studies have explored the influence of this variable while keeping other factors constant, such as pitch dimension: for example, Aguiar et al. [22] showed that

playing with 2*vs*. 2 can elicit HR responses around 90% of HRmax than 3- 4- 5- a – side. Furthermore, Brandes et al. [23] stated that 2 *vs*. 2 reveals significantly higher responses in the HR and blood lactate as compared with 3*vs*. 3 or 4*vs*. 4. Therefore, they suggested using 2 *vs*. 2 to increase aerobic fitness.

Although the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4 are presented as the most SSG used in elite soccer (1, 2, 8, 22), to the best of our knowledge, games rules (stop-ball *vs*. small-goals) within these three specifics SSG in very young soccer players was not yet investigated. Only the study of Halouani et al. [18] has compared SSG' physiological responses with stop-ball (SB-SSG) and small-goals (SG-SSG) rules on young players. However, these authors have only used one form of players' number (3 *vs*. 3).

Thus, the aim of the present study was to examine the influence of 3 forms of players' number (i.e., 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4) during Stop -Ball (SB-SSG) and Small- Goal (SG-SSG) rules on the physiological responses (i.e., HR, La, and RPE) of very young soccer players. However, further studies in SB-SSG and SG-SSG might investigate some comparisons with senior players, and could use GPS for more accurate data on the players' motion.

MATERIALS AND METHODS

Subjects

Eighteen young soccer players (average age 13.5±0.7 years; height 168.9±6.1cm; body mass 63.1±7.7 kg) voluntarily participated in this study. All the players were the members of the same youth team and played in amateur league (first level). They had an experience at least of 3 years of soccer training. Their standard training involved 3-4 sessions per week (each lasting around 90 minutes), playing a match every 3 weeks. All the players and their parents or legal guardians were notified of the research design and its requirements, as well as the potential benefits and risks, and each participant gave written informed consent prior to the start. The study protocol was approved by the ethic committee of the National Center of Medicine and Science in Sport, and the study design was designed in accordance with the Declaration of Helsinki 1964 and its further amendments.

Experimental procedure

To investigate the effects of players' number during SB-SSG and SG-SSG on physiological responses, 3 forms of players' number were employed (2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4) while pitch dimension was held constant (20×25m). The players performed 4×4 min SSG with 2 min of passive recovery in-between. All subjects were fully familiarized with the experimental procedures and the requirements of the games prior to participation in the main investigation. The players performed 6 training sessions: SB-SSG and SG-SSG for 3 forms of players' number. During the SB-SSG, the participants were instructed to stop the ball with the soles of their boots in a 20 × 1 m surface located behind the bottom line (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. However, during the SG-SSG, the subjects were instructed to score a goal in Small Goals placed at the center of the end line of the pitches. The goal dimensions were of 1m width and 0.5 m height (Figure1). During the SB-SSG and the SG-SSG, all participants were asked to defend and attack and no goalkeepers were used.

Before each session, players performed the usual 15 minutes of standardized warm-up that includes running at low intensities and dynamic stretching exercises followed by ball specific stretching with a final part of 5 min of ball conservation in order to get ready for the study specific task. The HR of each player was recorded at 5-Hz intervals during each SSG via short-range radio telemetry (Polar Team Sports System; Polar Electro Oy, Kempele, Finland) and the HRmax was calculated for all the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4. Global RPE were recorded immediately after each SSG using the 10-point scale [24]. Standardized instructions for RPE were provided. Players were already familiarized with the10-point scale before this study. Blood lactate concentration was measured with the Lactate Pro device (Arkray Inc, USA) 3 minutes after the end of each SSG form. This device has been shown to provide valid indications of blood lactate concentrations [25].All the sessions were at the same time of the day (16h to 18h) to avoid HR circadian rhythm variation[26].The experiment was performed during the first part of the competitive season (from the third week of November).

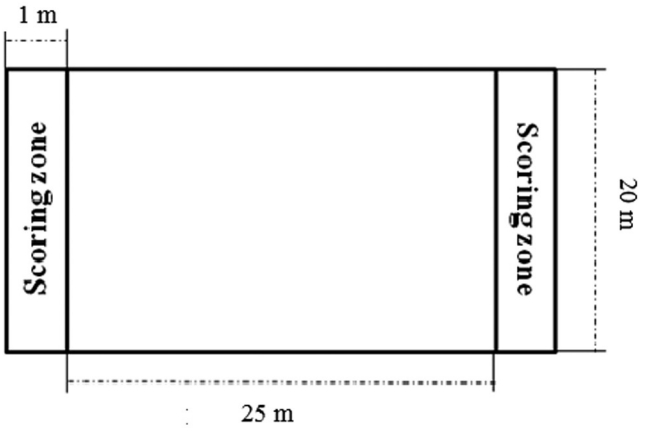

FIG. 1. Stop-ball small-sided games (Halouani et al., 2014).

Statistical analysis

Data were analyzed using a two way analysis of variance (ANOVA) [2 (games rules: SG- *vs*. SB-SSG) × 3 (players' number: 2 *vs*. 2, 3 *vs*. 3, and 4 *vs*. 4)]. The Fisher's LSD post hoc test was used to identify pairwise comparisons. All statistical analyses were performed using the software package STATISTICA (StatSoft ®, Maisons-Alfort, France) and significance was set at $P \leq 0.05$.

RESULTS

Heart rate

The statistical analysis showed significant main effect for the number of players ($F=57.5$, $p\leq0.001$, $\eta_p^2 = 0.8$) and game rule ($F=154.9$,

$p \leq 0.001$, $\eta_p^2 = 0.9$). However, there was no-significant interaction number of players × game rule ($F = 1.6$, $p > 0.05$, $\eta_p^2 = 0.1$).

The post hoc test revealed that HR values were significantly higher during SB-SSG than SG-SSG in the 2 *vs*. 2 ($p \leq 0.001$), 3 *vs*. 3 ($p \leq 0.001$) and 4 *vs*. 4 ($p \leq 0.001$) games ruless.

Likewise, the results indicated that HR values were significantly higher during the 3 *vs*. 3 game rule than the 2 *vs*. 2 and 4 *vs*. 4 games rules during SB-SSG ($p \leq 0.001$) and SG-SSG ($p \leq 0.001$). Also, during both SB-SSG and SG-SSG, HR values were significant higher during 2 *vs*. 2 than 4 *vs*. 4 ($p \leq 0.001$) game rule.

Moreover, the % HRmax calculated was significantly higher during SB-SSG than SG-SSG in the 3 *vs*. 3 as compared to 2 *vs*. 2 and 4 *vs*. 4 (Table 1).

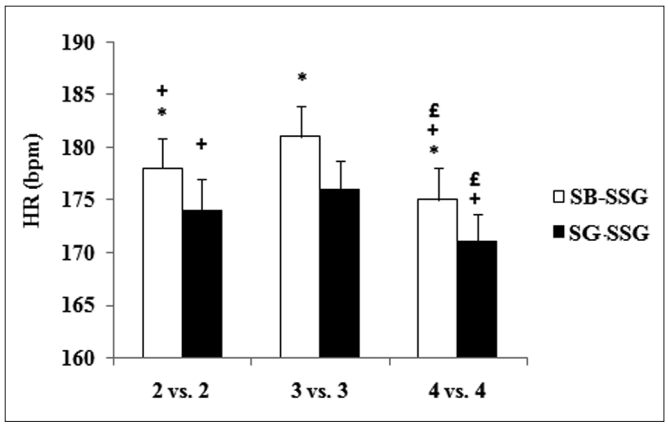

FIG. 2. HR recorded during the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4 SSG with stop ball situation (SB-SSG) and small goal situation (SG-SSG). *: significant difference in comparison with SB-SSG.; +: significant difference in comparison with 2 vs. 2, £: significant difference in comparison with 3 vs. 3

TABLE 1. HR values (bpm) and percentage of HRmax (%HRmax) during the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4 SSG with stop ball situation (SB-SSG) and small goal situation (SG-SSG).

Players' number	2 *vs.* 2	3 *vs.* 3	4 *vs.* 4
SB-SSG (bpm)	178±2.89*	181±2.86*	175±3.07*
SB-SSG (%HRmax)	86*	87.5*	84.7*
SG-SSG (bpm)	174±3.05	176±2.73	171±2.07
SG-SSG (%HRmax)	84.2	85	82.5

Note: *: significant difference in comparison with SB-SSG.

Rating of perceived exertion

The statistical analysis of RPE showed significant main effect for the number of players ($F = 4.58$, $p \leq 0.05$, $\eta_p^2 = 0.3$) and game rule ($F = 7.4$, $p \leq 0.05$, $\eta_p^2 = 0.4$). However, there was no-significant interaction number of players × game rule ($F = 0.07$, $p > 0.05$, $\eta_p^2 = 0.01$) on RPE.

The post hoc test revealed that RPE scores were significantly higher during SB-SSG than SG-SSG in the 2 *vs*. 2 game rule ($p \leq 0.05$). However, there was no-significant difference between SB-SSG and SG-SSG for the 3 *vs*. 3 and 4 *vs*. 4 games rules.

The results indicated also that RPE scores were significantly higher during the 2 *vs*. 2 game rule than the 4 *vs*. 4 game rule during SB-SSG ($p \leq 0.01$) and SG-SSG ($p \leq 0.05$). However, during both SB-SSG and SG-SSG, there were no significant differences between 2 *vs*. 2 and 3 *vs*. 3 and between 3 *vs*. 3 and 4 *vs*. 4.

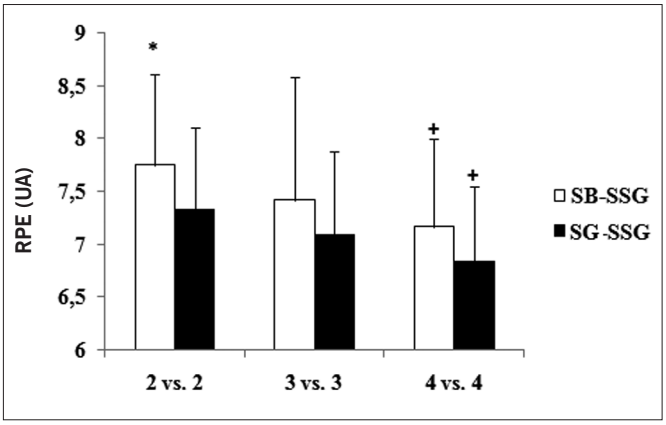

FIG. 3: RPE scores during the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4 SSG with stop ball situation (SB-SSG) and small goal situation (SG-SSG). *: significant difference in comparison with SB-SSG.; +: significant difference in comparison with 2 *vs*. 2.

Lactate concentrations

The statistical analysis of [La-] showed significant main effect for the number of players ($F = 10.8$, $p \leq 0.001$, $\eta_p^2 = 0.5$) and game rule ($F = 17.8$, $p \leq 0.001$, $\eta_p^2 = 0.6$). However, there was no-significant interaction number of players × game rule ($F = 0.3$, $p > 0.05$, $\eta_p^2 = 0.02$) on [La-].

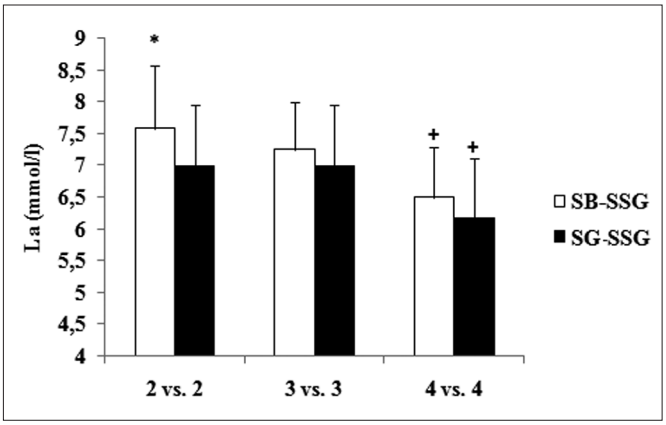

FIG. 4: [La-] recorded during the 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4 SSG with stop ball situation (SB-SSG) and small goal situation (SG-SSG). *: significant difference in comparison with SB-SSG.; +: significant difference in comparison with 2 *vs*. 2.

The post hoc test revealed that [La-] concentrations were significantly higher during SB-SSG than SG-SSG in the 2 *vs*. 2 game rule ($p \leq 0.05$). However, there was no-significant difference between SB-SSG and SG-SSG for the 3 *vs*. 3 and 4 *vs*. 4 games rules.

The results indicated also that [La-] concentrations were significantly higher during the 2 *vs*. 2 game rule than the 4 *vs*. 4 game rule during SB-SSG ($p \leq 0.001$) and SG-SSG ($p \leq 0.01$). However, during both SB-SSG and SG-SSG, there were no significant differences between 2 *vs*. 2 and 3 *vs*. 3 and between 3 *vs*. 3 and 4 *vs*. 4.

DISCUSSION

The aim of this study was to examine the physiological responses of 3 football SSG formats (i.e., 2-, 3-, and 4-a-side) with 2 games rules (i.e., stop-ball *vs*. small goal rules) while maintaining the pitch area constant (i.e., 20×25m) in young soccer players. The main results of the present study showed that SB-SSG induced higher HR, RPE and [La-] responses than SG-SSG for the 3 game formats. However, RPE scores and [La-] were significantly higher in SB-SSG compared to SG-SSG only in the 3 *vs*. 3 forms. Moreover, the present study also showed that the higher physiological response to SSG was observed during 3 *vs*. 3 for SB- SSG. For the 2 *vs*. 2 the best indicator is RPE whereas for the 3 *vs*. 3 and 4 *vs*. 4, the others parameters analyzed provide also interesting information.

The present study's results showed that HR was significantly higher during SB-SSG than SG-SSG for the 3 forms of players' number (i.e., 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*.4). Moreover, according to HRmax SB-SSG induce higher intensities comparing to SG-SSG (86 *vs*. 84.2; 87.5 *vs*. 85 and 84.7 *vs*. 82.5 %, respectively). To the best of our knowledge, only the study of Halouani et al. [18] was compared the physiological responses to SB-SSG *vs.* SG-SSG on young soccer players using 3 *vs*. 3 formats. As observed in the present study, the authors reported a higher SSG intensity (i.e., higher HR values) during the SB-SSG than the SG-SSG. These findings could be explained by: (i) the larger area to be covered during the SB-SSG in both the defensive and the offensive phases, (ii) a higher motivation during the SB-SSG format (i.e., new situation and new form of scoring; 12), and (iii) the technical abilities (i.e., the SB-SSG required less technical abilities than SG-SSG as the scoring zone is large). The present study confirmed the results of Halouani et al. [18] during the 3 *vs.* 3 SSG and demonstrated that the higher HR responses to SSG are observed in all playing number format (i.e., 2 *vs*. 2, 3 *vs*. 3 and 4 *vs*. 4). These findings reflect the effectiveness of SB-SSG for increasing the soccer training intensity.

The results of the present study, also, showed a higher HR values during the 3 *vs*. 3 SSG than the 2 *vs*. 2 and 4 *vs*. 4 during both SB-SSG and SG-SSG. In agreement, Dellal et al. [8] have investigated the effects of 3 forms of players' number (i.e., 2 *vs*. 2, 3 *vs*. 3 and 4 *vs.* 4) in HR responses to SSG on youth soccer players. The authors reported that the higher values of HRreserve were recorded during 3 *vs*. 3 compared to 2 *vs*. 2 and 4 *vs*. 4 SSG (80.1% *vs.* 81.5% *vs.* 70.6%, respectively during 2 *vs*. 2; 3*vs*. 3 and 4 *vs.* 4). Recently, Aguiar et al. [22] found that the higher percentage of HRmax values was found in3- a-side formats (89.56%) in comparison with 2- 4 and 5 – a-side (87.46; 85.91 and 84.56%, respectively). Therefore, using the 3 *vs*. 3 formats seems more adequate when aiming for increasing the training intensity for soccer player. The results of the present study confirmed those of Dellal et al. [8] and Aguiar et al. [22] and demonstrated that this higher training intensity is observed not only during the SG-SSG, but also during the SB-SSG.

Exercise intensity in SSGs is not only established by measuring players' HR responses during the game, but also utilizing post-SSG RPE and[La-] variations [27, 28]. In this study, 2*vs*. 2 formats elicited a statistically significant greater RPE and [La-] value during SB-SSG than SG-SSG in comparison with the other 2formats (i.e., 3- and 4-a-side). However, there was no-significant difference between SB-SSG and SG-SSG for the 3 *vs*. 3 and 4 *vs*. 4 games rules.

These results are similar to those previously reported by Hill-Hass et al. [29], Rampinini et al. [28] and Sampaio et al. [30]. This suggests that RPE and [La-] increases when the number of players decline. In this context, Hill-Haas et al. [29] suggested that as the number of players decreased during SSG,[La-] responses to SSG increased (i.e., higher concentrations). Similarly, Köklü et al. [31] found that decreasing the number of players resultedin increased [La-] responses to SSG. Also, Rampinini et al. [28] have already identified higher RPE values in reduced SSG formats (i.e., reduced the number of players).

One of the reasons for these findings is when the pitch size per player is increased, the intensity and the involvement in the game might be decreased [12]. Also, another explanation for the reduction in RPE and [La-] with the increasing number of players may be the decreasing interaction with colleagues and opponents [22]. Moreover, reducing the number of players increases the RPE and [La-], this fact may be explained by the greater need of players to be moving to create several passing opportunities, because the reduction in the number of players on the field reduces the number of possible solutions and lowers team ball possession but increases the interaction of each player with the ball or opponents [32].

In this study, results showed that the higher HR response to SSG was observed during 3 *vs*. 3 for SB SSG. In contrast, the higher values of RPE and [La-] were found in 2 *vs*. 2 also for SB SSG. Aguiar et al. [22] have compared the physiological responses (i.e., HRmax and RPE) of 4 forms of players' numbers (i.e., 2 *vs*. 2; 3 *vs*. 3; 4 *vs*. 4 and 5 *vs*. 5). In this study, the authors concluded that 2 *vs*. 2 format elicited a statistically significant greater RPE value (17.01 ± 2.88) and the last format (5-a-side) presented the lowest value (15.00 ± 2.25). However, concerning HRmax responses, the 3-a-side formats elicited a higher percentage than the 2- 4- and 5-a-sidegames (87.46 *vs*. 89.56 *vs*. 85.91 *vs*. 84.56 %, respectively to 2 *vs*. 2; 3 *vs*. 3; 4 *vs*. 4 and 5 *vs*. 5).

Similarly, Köklü [24] has reported a higher [La-] values for 2 *vs*. 2 format (8.1±1.7 mmol·$L^{-1}L^{-1}$) and a higher HR values for 3 *vs*. 3 format (181.7±5.7 b·$L^{-1}min^{-1}$) when comparing physiological responses to various intermittent and continuousSSGs including 2-a-side, 3-a-side, and 4-a-side games in young soccer players.

The present study also found 3-a-side HR responses to be significantly higher than those in 2-a-side and 4-a-side formats. The reason of this finding could be that 3-a-side have a lower relative pitch ratio per player than 2-a-side. When the pitch size per player is increased, the intensity and the involvement in the game might be decreased[12].

Moreover, technical actions such as the number of ball contacts may increase RPE and [La-] concentration, especially in SSGs including fewer players[12]. Capranica et al.[33] compared the physiological responses of 11-a-side *vs*.7-a-side small games and they suggested that the less number of players, the more ball contacts from all players. This appears to support the present results as players touched and dribbled the ball more often during the 2 *vs*. 2 game compared with the 3-4 -a-side game. Reilly and Ball, [34] reported an increase in RPE and[La-] when dribbling a ball for several minutes, probably due to the extra muscular activity required to control the ball and to propel it forward. Although continuous dribbling applied by Reilly and Ball [34] is not the same as the total number of dribbles and ball contacts recorded in this study, the higher number of dribbles and ball contacts could have partly contributed to a higher exercise intensity observed in 2 *vs*. 2 games compared with the 3-4 -a-side game.

Furthemore, this increase during 2 *vs*. 2 is due to the greater low intensity actions and the low rest period during the game in comparison with 3 *vs*. 3 and 4 *vs*. 4. Available research has identified increases in frequency of technical actions in SSGs with fewer players [35]. These authors showed a higher number of short passes and dribbles were found during the smaller format of players' number. This suggest that increased pressure from the opponents and this situation requires from the players to cooperate more often via short and quick passes dribble in order to avoid the opponent's pressure. This quickness of actions reduces the rest period of players [4]. In the same context, Dellal et al. [8] demonstrated that the number of players influences the technical difficulty and the high-intensity actions. For the fewer players' number, the players are always concentrated on the play and have to be continuously moving in order to create spaces by the means of turns, direction changes or sprints. These high-intensity actions are suggested to be linked to the greater technical difficulty combined to the possible lower duration to perform particular technical actions. The players have to perform the offensive actions (passes, dribbling and strikes at the goal) and the defensive actions (tackling and pressure on the players who have the ball) more quickly and at a greater frequency[8]. This fact influence the recovery time of each player during the game and reduce this period in comparison with 4 *vs*. 4.

CONCLUSIONS

To conclude, the present study reveals that the SB-SSG induce the higher physiological responses in comparison with SG-SSG for the 3 game formats (i.e., 2 *vs*. 2; 3 *vs*. 3 and 4 *vs*. 4). Moreover, this study also showed that the higher values of HR were observed during 3 *vs*. 3 and the higher RPE and [La-] values were recorded during 2 *vs*. 2 for SB SSG than SG SSG. Therefore, the use of 2 *vs*. 2 and 3 *vs*. 3 SSG with SB-SSG seems to represent an alternative to coaches to increase cardiovascular and metabolic demands in youth soccer players. This information is useful for coaches because they can modify or introduce rules in the SSG formats to adjust them to the competition demands.

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