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Small-sided games in amateur players: rule modification with mini-goals to induce lower external load responses

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ABSTRACT: The aim of this study was to compare the acute physiological (i.e., heart rate-related variables) and neuromuscular responses (i.e., sprint and jump) and time-motion characteristics (i.e., external load variables) when modifying the game design (possession play vs. mini-goals without a goalkeeper) during 4-a-side in amateur senior football players. Male senior football players (n = 16) performed two formats of small-sided games (SSGs) in two different testing sessions (4-a-side with possession play and mini-goals rule). Differences in time-motion characteristics and physiological parameters of players were measured with the Global Positioning System (GPS), and tested before and after (pre- and post-SSG) for neuromuscular assessment. A repeated measures analysis of variance (ANOVA), with Bonferroni post-hoc test, showed that both SSG formats induced changes in sprint performance (before-after comparison) ($p \leq 0.05$). Moreover, the results showed that the variables muscle oxygen saturation, rate of perceived exertion, 85–89% heart rate peak, total distance, total distances at low speed, total distances at high speed, m/min, accelerations at low speed, accelerations of ≥ 2.5 m.s^{-2}, maximal speed, and average speed were statistically significantly different among game conditions. The players' performances are affected by the inclusion of mini-goals during 4 vs. 4 SSGs. The results provide useful information for training and task design that replicate specific physical demands (i.e., accelerations of ≥ 2.5 m.s^{-2}, total distances at high speed or total distances at low speed).

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INTRODUCTION

One of the most important issues for enhancing performance in sports is that the maximum benefits are achieved when the training stimuli are similar to competitive demands [1]. Small-sided games (SSGs) are characterized by simulating real match conditions [2]. The principle of specificity justifies the use of these kinds of drills in training [3], so SSGs are thought to be more suitable than traditional interval training for the development of particular physical characteristics required for matches as they involve the actual movement patterns used in football [4, 5]. Moreover, SSGs have shown their effectiveness in improving athletic performance in football players [6].

The nature of the effort performed during the SSGs can be modified by the coaches according to the aims of training by changing several variables such as the number of players [7], dimensions of the playing area [8], the playing rules (possession play, regular goals or mini-goals) [9], among others. Understanding the effect of varying external factors on both exercise intensity and technical scores would allow better integration of SSGs within the whole football training process [10]. However, some studies show that it is difficult to make accurate conclusions based on the influence of each of these factors in isolation due to the heterogeneity of the studies [11]. Furthermore, when more than one variable is manipulated simultaneously, responses are more difficult to predict because of the different nature and inter-relation of the stimulus [10]. So, caution should be exercised when interpreting the findings of a study, owing to the heterogeneity that exists among study protocols.

As mentioned above, another factor that influences the SSG outcomes could be the games' rules. In that regard, Aguiar et al. [12] did not find a study about the effect of mini-goals on the physiological and physical response of players during SSG. However, Giménez et al. [13] reported information about physical responses of football players during SSGs played with mini-goals. Recently, some authors [14] studied the influence of the number of goal-posts and the positioning of goal-posts used within SSGs on the frequency of technical actions and offensive scenarios, but not on physiological and physical variables. Moreover, a study of Halouani et al. [15] compared 3 forms of players' numbers (2-a-side, 3-a-side and 4-a-side) during two different games rules of SSGs (stop-ball vs. small-goals rules) and observed that all SSG formats with the stop-ball rule increase cardiovascular and metabolic demands in youth football players. In addition, when using the stop-ball conditions in comparison with the small-goal rule for several pitch sizes (4-a-side) higher physiological responses were observed in the stop-ball conditions for all pitch sizes [16]. In the same way, when possession play was used in SSGs, the intensity was greater than in SSGs with goalkeepers or mini-goals [17].

The SSGs with mini-goals may suggest other task options that can be used to modify the physiological and physical training load [13]. In this sense, coaches simulate football-specific training drills using principles of play and a game model in the same training task [18]. So, the SSGs with mini-goals must be considered with a training skill format, because they are not only adequate, but also more specific than the SSG (maintenance) format, combining high intensity of workload and short time for recovery (physiological adaptation). In this format, shot accuracy is necessary and the players' finishing potential can be improved with training. Thus, this type of SSG requires good technical demands such as precision in passing and shooting, determining aspects in the performance of a football game.

In this context, recent technological advances now allow for movement characteristics of football players to be collected [19]. This information may be used to design game-related conditioning activities [19]. Specifically, the portable Global Positioning System (GPS) micro-technology is now used by professional football to quantify the movement demands on players during training and games [19]. Other technological advances such as muscle oxygen saturation (SmO_2) and total muscle haemoglobin (THb) can be analysed as acceptable indices of metabolic demand in the working muscle (negatively correlated with heart rate [HR]) [20].

Although the manipulation of scoring type [15] and possession play [17] has been reported to affect the physiological responses to SSGs (as mentioned above), no previous study has compared the physiological and time-motion characteristics to the SSG played with the possession play rule (PP-SSG) and the SSG played with the mini-goals rule (MG-SSG) in amateur senior football players. Additionally, the influence of MG-SSG on the neuromuscular response has not yet been investigated. Having said this, and because these are two of the formats most used in football training, the authors of the present study decided to compare the effects of both formats on amateur players. Therefore, the aim of this study was to compare the acute physiological (i.e., HR-related variables, rating of perceived exertion [RPE], SmO_2 and THb) and neuromuscular responses (i.e., sprint and jump) and time-motion characteristics (i.e., external load variables) when modifying the game design (possession play vs. mini-goals) during 4-a-side in amateur senior football players. It was hypothesised that the PP-SSG would provide a more intense physical and physiological stimulus, and worse neuromuscular performance compared with the MG-SSG.

MATERIALS AND METHODS

Experimental approach to the problem

To investigate the effects of the game design (possession play vs. mini-goals) during 4-a-side SSG on physiological and neuromuscular responses, and time-motion characteristics, two formats of SSG were employed while pitch dimensions were held constant (30x20 m) [21]. The SSGs consisted of 2 trials (a total of 8 repetitions of 4-min game situations), interspersed by 2 min of passive recovery. Each trial included four repetitions of 4 vs. 4 SSGs with a game duration of 4 minutes. All the athletes performed 2 training sessions distributed over a 4-week time span during the first round of the in-season period (from November to December in 2019). Moreover, all training sessions were done once per week and the same day of the microcycle (Wednesday) about 9:00 p.m. The players were randomized to 2 SSG formats: PP-SSG and MG-SSG (without a goalkeeper). During the PP-SSG, the participants were instructed to maintain ball possession as long as possible, with no restrictions regarding number of ball touches. However, during the MG-SSG, the players were instructed to score a goal in two mini-goals, placed at the centre of the end line of the pitches, and no goalkeepers were used. A goal is scored by passing/shooting the ball at the goal and all teammates have crossed the midline of pitch at that moment. The goal dimensions were 1.23 m width and 0.82 m height. In both SSGs, when the ball was kicked out of play, a ball replacement was immediately provided. The athletes were previously familiar with the different task formats, because they were part of their regular training, and the GPS technology.

Subjects

Sixteen male senior football players (age, 23.9 ± 4.2 years, body mass 74.9 ± 5.6 kg, body fat 13.2 ± 3% and football experience of 12 ± 4 years) from two amateur teams with similar competitive and training schedules successfully completed the study. The study was conducted during the in-season. Inclusion criteria to participate in the study were follows: (i) Standard training involved three 2.6 ± 0.5 hours training sessions per week, and a weekly league match, (ii) participants had been involved in regular football training for at least two years prior to the study, (iii) the players must have played more than 65 minutes of total playing time during the regular league match, and (iv) players had no injuries in the last six months. Measurements were performed as part of their regular training and testing programme, and players approved the use of these data for research purposes. Moreover, players and coaches were fully informed about the potential risks and benefits derived from participation in the study protocol. The participants provided their informed written consent to participate before starting field testing in accordance with the requirements of the Declaration of Helsinki (2013 version). The university ethics committee of the Faculty of Jaen approved this study. Moreover, the research received formal approval from the Football Club.

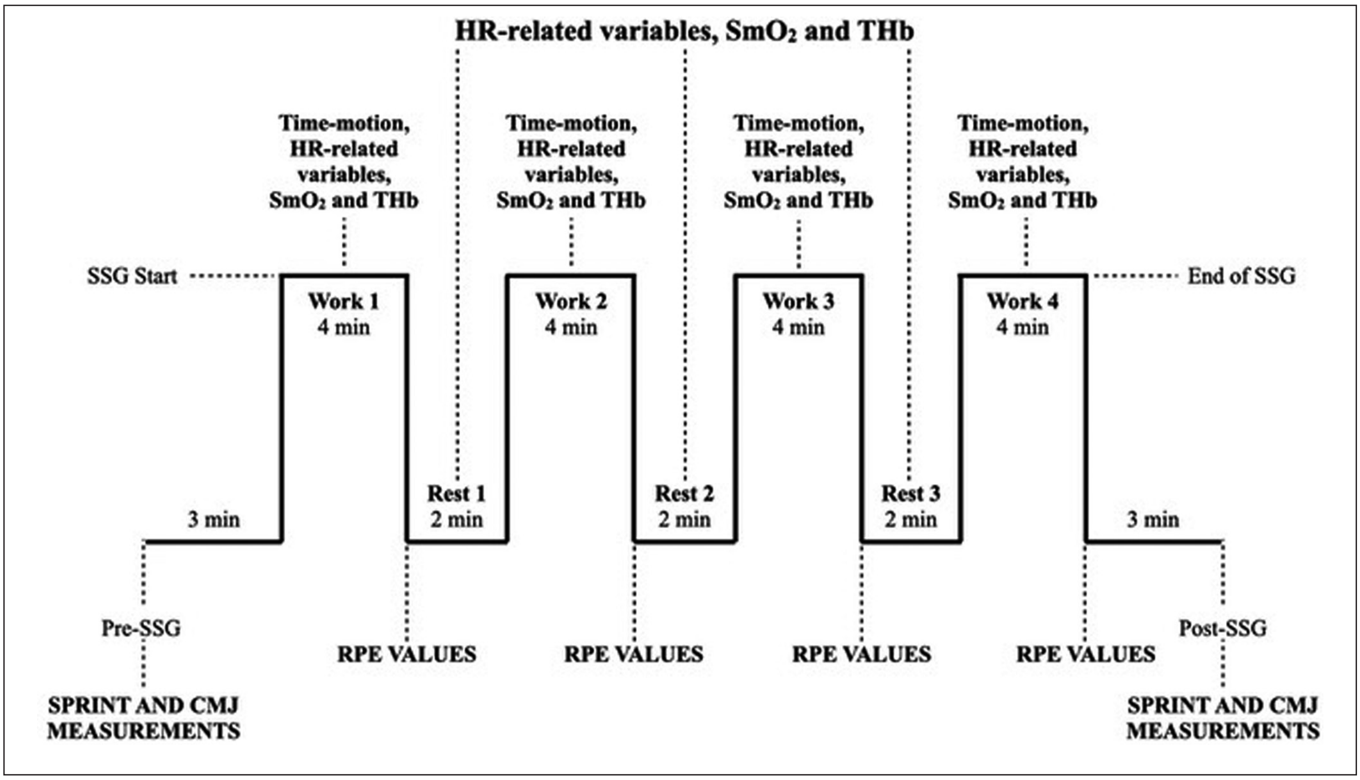

FIG. 1. Schematic diagram of the experimental protocol and variable measurements followed in both SSG formats.

Procedures

This is a single group repeated-measures study, in which all participants performed the two formats of SSG in two different testing sessions. Each session was separated by a week. During both sessions, the players were monitored for external load (time-motion characteristics) and physiological parameters during PP-SSG and MG-SSG, and tested before and after (pre- and post-SSG) for physical fitness assessment (countermovement vertical jump [CMJ], 5-m and 20-m sprint) (Figure 1). The SSGs were performed at the beginning of training to ensure that players were not exhausted. Each session began with the same 20-minute period of a typical warm-up [22], followed by the same football-specific passing game, which lasted another 10 minutes. The players were asked to avoid high-intensity exercise ≥ 72 h before the testing sessions (Thursday). All the game situations were performed on an outdoor artificial grass pitch, and participants wore official clothing and football boots. The players were motivated to perform at maximal intensity in every test.

Materials and testing

Physical fitness assessment

20-m sprint. Sprint evaluation (pre- and post-SSG) was accomplished through a speed test that was carried out in a straight 20 m line [23]. Additionally, split sprint time of 5 m was analysed. Sprint times (s) were measured using two double-light barriers (Witty; Microgate Srl, Bolzano, Italy; accuracy of 0.001 s). The players performed 2 trials with a 3 min recovery in-between. The best trial was recorded for the subsequent statistical analysis.

Countermovement vertical jump (CMJ). The jumping performance (pre- and post-SSG) was assessed through the CMJ test. The participants were highly familiarized with the CMJ technique [24], as they performed the CMJ in their daily training sessions. The CMJ was recorded using the OptoGait system (Microgate, Bolzano, Italy), which was also used in a similar study [25]. Players performed three trials with a 15-second recovery period between them, and the best trial was used for the statistical analysis.

Physiological and perceptual characteristics

Rating of perceived exertion (RPE). Global RPE was obtained, immediately after each of the 4 bouts of the SSG (during the recovery between bouts), from the players by asking “How hard was the SSG?”, using the 6–20 scale [26, 27]. Familiarization with the RPE scale was completed before the SSG.

Heart rate (HR) monitoring. The HR was recorded at 5-s intervals during the 4-a-side SSG via short-range radio telemetry (Polar Team Sport System, Polar Electro Oy, Finland). It was expressed as a percentage of peak HR (HRpeak), the maximal HR reached by the athlete in SSG, by using the generalized equation for predicting HRpeak [28], and was classified into four previously defined intensity zones: Zone 1 (< 75% HRpeak), Zone 2 (75–84% HRpeak), Zone 3 (85–89% HRpeak), and Zone 4 (≥ 90% HRpeak) [29]. The percentage of time spent within each intensity zone during the SSG was quantified, as well as the percentages of HRpeak (%HRpeak), and average HR (HRaverage), calculated through the generalized equation proposed by Tanaka et al. [28]. In addition, the HRpeak reached was recorded during the work and recovery periods of SSG.

Muscle oxygen saturation (SmO2) and total muscle haemoglobin (THb). The SmO_2 and THb were monitored by near infrared spectroscopy (Moxy, Fortiori Design LLC, Minnesota, USA), which was also used in similar studies [20, 30]. The Moxy was positioned on the participant's dominant leg, as in a previous study [20], determined by asking the athletes about their preferred kicking leg. The Moxy is a reliable device to measure SmO_2 and THb, validated in a previous study [20].

Time-motion characteristics

Players' activity was recorded using a 20-Hz Global Positioning System device (WIMU PRO) and was analysed using S PRO software (RealTrack Systems, Almeria, Spain). The reliability and validity of this technology for monitoring players' activity during football matches have been previously determined [31]. For data analysis purposes, 4 speed zones were selected: speed zone 1 (standing and walking, 0.1–6.9 km/h), speed zone 2 (low-intensity running, 7.0–12.9 km/h), speed zone 3 (medium-intensity running, 13.0–17.9 km/h), and speed zone 4 (high-intensity running, ≥ 18.0 km/h) [32, 33]; and 4 acceleration zones: acceleration zone 1 (1.0–1.4 m/s^2), acceleration zone 2 (1.5–1.9 m/s^2), acceleration zone 3 (2.0–2.4 m/s^2), and acceleration zone 4 (≥ 2.5 m/s^2) [32]. Similarly to previous studies, sprint distance was established (> 24.1 km/h) [34]. The total distance travelled, total m/min, total accelerations and decelerations, sprints, average sprint duration, maximal speed reached, average speed and distance travelled within designated speed zones and the number of accelerations within designated zones were all calculated.

Statistical analysis

Descriptive statistics are represented as mean and standard deviation (SD). Student's paired t-test was conducted to determine the pre- vs. post-SSG differences in physical fitness assessment (CMJ and sprint test). A repeated measures analysis of variance (ANOVA), with Bonferroni post-hoc test, was used to determine the dynamics of physiological parameters, RPE and time-motion characteristics during the SSG protocol. The magnitude of the differences between values was also interpreted using the Cohen's d effect size (*ES*) (between-group differences) [35]. Effect sizes are reported as: trivial (< 0.2), small (0.2–0.49), medium (0.5–0.79), and large (≥ 0.8) [35]. Data analysis was performed using SPSS (version 22, SPSS Inc., Chicago, IL, USA), and the significance level was set at $p \leq 0.05$.

RESULTS

Physical fitness assessment

Table 1 shows the physical fitness comparison (sprint and jump) between the two different formats of SSGs. No significant differences (Time × Group) in 20-m sprint, 5-m sprint, or CMJ were found ($p > 0.05$, ES < 0.3). However, significant differences (Group × Time) were found in 20–m sprint time ($p \leq 0.05$) for PP-SSG and in 5-m sprint time ($p \leq 0.05$) for MG-SSG.

TABLE 1. Physical fitness comparison (Mean ± *SD*) between two different formats of small-sided games in amateur football players (n = 16).

Variables	Groups	Before	After	P-value (group × time)
20-m sprint (s)	PP-SSG	3.11 ± 0.14	3.15 ± 0.12	0.027
	MG-SSG	3.14 ± 0.09	3.16 ± 0.09	0.426
p-value (time × group) (ES)		0.419 (0.3)	0.771 (0.1)	
5-m sprint (s)	PP-SSG	1.08 ± 0.08	1.09 ± 0.05	0.465
	MG-SSG	1.07 ± 0.06	1.10 ± 0.05	0.047
p-value (time × group) (ES)		0.657 (0.1)	0.691 (0.2)	
Countermovement jump (cm)	PP-SSG	39.1 ± 5.5	38.9 ± 5.8	0.713
	MG-SSG	38.0 ± 5.2	39.0 ± 5.2	0.145
p-value (time × group) (ES)		0.571 (0.2)	0.962 (0.1)	

ES = Cohen´s d effect size; PP-SSG = small-sided games with possession play rule; MG-SSG = small-sided games with mini-goals rule.

TABLE 2. Physiological and perceptual responses comparison (Mean ± *SD*) between two different formats of small-sided games (i.e., PP-SSG vs. MG-SSG) in amateur football players on bout periods (n = 16).

Variables	Groups	Bout 1	Bout 2	Bout 3	Bout 4	P-value (group × time)	Post-hoc analysis
Total haemoglobin content ($g.dL^{-1}$)	PP-SSG	12.1 ± 0.5	12.2 ± 0.5	12.1 ± 0.5	12.1 ± 0.5	0.420	
	MG-SSG	11.9 ± 0.2	12.0 ± 0.2	12.0 ± 0.2	12.0 ± 0.2	0.638	
p-value (time × group) (ES)		0.466 (0.4)	0.552 (0.4)	0.648 (0.2)	0.498 (0.2)		
Muscle oxygen saturation (%)	PP-SSG	36.3 ± 15.3	38.4 ± 17.4	34.0 ± 13.2	34.3 ± 15.3	0.380	
	MG-SSG	42.6 ± 11.7	49.7 ± 19.0	52.0 ± 16.0	50.5 ± 13.4	0.093	
p-value (time × group) (ES)		0.420 (0.4)	0.267 (0.5)	0.040 (1.2)	0.062 (1.1)		
Rating of perceived exertion (6–20)	PP-SSG	12.3 ± 1.5	13.0 ± 1.9	13.6 ± 1.2	14.5 ± 1.9	< 0.001	Bout1 < Bout 2*,3**,4*** Bout 2 < Bout 4*** Bout 3 < Bout 4**
	MG-SSG	10.8 ± 1.1	11.0 ± 1.6	11.4 ± 1.6	11.6 ± 1.8	0.312	
p-value (time × group) (ES)		0.003 (1.1)	0.005 (1.1)	< 0.001 (1.4)	< 0.001 (1.6)		
HR_{peak} (beats . min^{-1})	PP-SSG	169.12 ± 23.94	173.93 ± 17.59	171.37 ± 20.96	172.25 ± 18.66	0.179	
	MG-SSG	167.00 ± 12.14	169.93 ± 15.12	168.21 ± 17.38	167.93 ± 19.30	0.605	
p-value (time × group) (ES)		0.767 (0.1)	0.512 (0.2)	0.659 (0.2)	0.538 (0.3)		
Average HR (beats . min^{-1})	PP-SSG	157 ± 23.9	161 ± 19.4	160 ± 18.6	159 ± 20.2	0.570	
	MG-SSG	153 ± 10.1	156 ± 14.7	154 ± 15.0	153 ± 17.9	0.642	
p-value (time x group) (ES)		0.515 (0.2)	0.472 (0.3)	0.350 (0.3)	0.345 (0.3)		
$\%HR_{peak}$ (%)	PP-SSG	87.0 ± 10.5	88.9 ± 8.3	88.5 ± 6.9	88.3 ± 8.6	0.553	
	MG-SSG	87.0 ± 2.5	88.7 ± 4.1	87.6 ± 4.4	86.9 ± 7.1	0.689	
p-value (time x group) (ES)		0.979 (0.1)	0.930 (0.1)	0.673 (0.1)	0.635 (0.2)		
< 75% HR_{peak} (%)	PP-SSG	25.6 ± 34.5	21.3 ± 30.6	19.6 ± 32.6	20.5 ± 34.1	0.663	
	MG-SSG	14.6 ± 7.9	13.6 ± 15.8	16.1 ± 25.1	23.2 ± 28.6	0.713	
p-value (time x group) (ES)		0.255 (0.4)	0.407 (0.3)	0.747 (0.1)	0.817 (0.1)		
75–84% HR_{peak} (%)	PP-SSG	10.3 ± 8.7	14.5 ± 10.4	13.7 ± 15.3	11.6 ± 11.0	0.866	
	MG-SSG	21.4 ± 21.5	16.9 ± 13.2	20.1 ± 25.1	16.8 ± 13.6	0.481	
p-value (time x group) (ES)		0.067 (0.6)	0.568 (0.1)	0.399 (0.3)	0.261 (0.4)		
85–89% HR_{peak} (%)	PP-SSG	7.7 ± 5.8	7.5 ± 7.8	10.7 ± 13.6	10.8 ± 10.0	0.673	
	MG-SSG	22.2 ± 18.5	16.9 ± 15.2	16.9 ± 14.0	14.7 ± 16.4	0.176	
p-value (time x group) (ES)		0.006 (1.1)	0.037 (0.7)	0.224 (0.4)	0.435 (0.3)		
> 90% HR_{peak} (%)	PP-SSG	56.4 ± 30.5	56.8 ± 32.0	56.0 ± 31.4	57.0 ± 32.2	0.998	
	MG-SSG	41.7 ± 33.9	52.5 ± 26.7	46.8 ± 24.9	45.2 ± 28.9	0.541	
p-value (time x group) (ES)		0.223 (0.4)	0.693 (0.1)	0.386 (0.3)	0.305 (0.4)		

PP-SSG = small-sided games with possession play rule; MG-SSG = small-sided games with mini-goals rule; ES = Cohen´s d effect size (between groups); HR_{peak} = peak heart rate; $\%HR_{peak}$ = percentage of HR_{peak}; < 75% HR_{peak} (%) = the percentage of time spent within that intensity zone; 75–84% HR_{peak} (%) = the percentage of time spent within that intensity zone; 85–89% HR_{peak} (%) = the percentage of time spent within that intensity zone; > 90% HR_{peak} (%) = the percentage of time spent within that intensity zone; post-hoc: * < 0.05, ** < 0.01 and *** < 0.001.

TABLE 3. Physiological responses comparison (Mean ± *SD*) between two different formats of small-sided games (i.e., PP-SSG vs. MG-SSG) in amateur football players on recovery periods (n = 16).

Variables	Groups	Recovery between bout 1–2	Recovery between bout 2–3	Recovery between bout 3–4	P-value (group x time)
Total haemoglobin content ($g.dL^{-1}$)	PP-SSG	12.4 ± 0.4	12.2 ± 0.5	12.4 ± 0.3	0.160
	MG-SSG	12.3 ± 0.1	12.3 ± 0.1	12.3 ± 0.1	0.894
p-value (time x group) (ES)		0.745 (0.3)	0.383 (0.3)	0.837 (0.4)	
Muscle oxygen saturation (%)	PP-SSG	66.7 ± 8.7	65.2 ± 9.9	61.1 ± 15.4	0.350
	MG-SSG	68.4 ± 8.6	70.7 ± 8.8	72.9 ± 6.2	0.565
p-value (time x group) (ES)		0.714 (0.2)	0.304 (0.6)	0.106 (1.0)	
HR_{peak} (beats . min^{-1})	PP-SSG	167 ± 24.5	169 ± 20.1	165 ± 23.1	0.395
	MG-SSG	164 ± 12.7	164 ± 16.1	164 ± 15.8	0.688
p-value (time x group) (ES)		0.701 (0.1)	0.496 (0.3)	0.795 (0.1)	
$HR_{average}$ (beats . min^{-1})	PP-SSG	143 ± 17.7	144 ± 11.3	145 ± 16.9	0.877
	MG-SSG	136 ± 15.2	138 ± 13.5	135 ± 13.2	0.524
p-value (time x group) (ES)		0.272 (0.4)	0.184 (0.5)	0.092 (0.7)	
$\%HR_{peak}$ (%)	PP-SSG	79.2 ± 8.8	79.8 ± 3.4	80.1 ± 6.7	0.913
	MG-SSG	77.6 ± 7.7	78.4 ± 5.8	76.9 ± 5.6	0.526
p-value (time x group) (ES)		0.592 (0.2)	0.449 (0.3)	0.166 (0.5)	
< 75% HR_{peak} (%)	PP-SSG	42.1 ± 34.0	36.8 ± 33.5	41.5 ± 38.9	0.768
	MG-SSG	47.8 ± 29.6	45.6 ± 30.7	41.2 ± 24.6	0.633
p-value (time x group) (ES)		0.631 (0.2)	0.460 (0.3)	0.978 (0)	
75–84% HR_{peak} (%)	PP-SSG	29.2 ± 25.2	26.2 ± 18.0	22.2 ± 17.6	0.649
	MG-SSG	26.7 ± 25.0	26.0 ± 24.6	38.47 ± 23.7	0.178
p-value (time x group) (ES)		0.782 (0.1)	0.983 (0)	0.040 (0.8)	
85–89% HR_{peak} (%)	PP-SSG	9.1 ± 5.8	11.9 ± 9.3	13.6 ± 18.9	0.150
	MG-SSG	5.9 ± 5.0	10.8 ± 7.5	8.8 ± 7.5	0.089
p-value (time x group) (ES)		0.124 (0.6)	0.714 (0.1)	0.374 (0.3)	
> 90% HR_{peak} (%)	PP-SSG	19.6 ± 16.6	18.9 ± 13.1	22.7 ± 25.7	0.740
	MG-SSG	19.6 ± 30.1	17.6 ± 16.3	11.6 ± 6.9	0.533
p-value (time x group) (ES)		0.997 (0)	0.817 (0.1)	0.129 (0.6)	

PP-SSG = small-sided games with possession play rule; MG-SSG = small-sided games with mini-goals rule; ES = Cohen´s d effect size (between groups); HR_{peak} = peak heart rate; $\%HR_{peak}$ = percentage of HR_{peak}; < 75% HR_{peak} (%) = the percentage of time spent within that intensity zone; 75–84% HR_{peak} (%) = the percentage of time spent within that intensity zone; 85–89% HR_{peak} (%) = the percentage of time spent within that intensity zone; > 90% HR_{peak} (%) = the percentage of time spent within that intensity zone; post-hoc: * < 0.05, ** < 0.01 and *** < 0.001.

TABLE 4. Time-motion characteristics comparison (Mean ± *SD*) during two different formats of small-sided games (i.e., PP-SSG vs. MG-SSG) in amateur football players (n = 16).

Variables	Groups	Bout 1	Bout 2	Bout 3	Bout 4	P-value (group x time)	Post-hoc Analysis
Total distances (m)	PP-SSG	532 ± 48.3	515 ± 59.5	500 ± 53.4	512 ± 42.9	0.005	Bout 1 > Bout 3**
	MG-SSG	482 ± 53.3	455 ± 45.8	432 ± 34.2	441 ± 41.3	< 0.001	Bout 1 > Bout 3*** Bout 1 > Bout 4*
p-value (time x group) (ES)		0.013 (1)	0.005 (1.1)	< 0.001 (1.5)	< 0.001 (1.7)		
Total distances at 0.1–6.9 km.h^{-1} (m)	PP-SSG	179 ± 20.9	183 ± 23.7	200 ± 28.0	193 ± 17.8	0.003	Bout 1 < Bout 3** Bout 1 < Bout 4* Bout 2 < Bout 3*
	MG-SSG	213 ± 16.6	217 ± 20.3	218 ± 22.6	220 ± 21.6	0.548	
p-value (time x group) (ES)		< 0.001 (1.8)	< 0.001 (1.5)	0.060 (0.7)	0.001 (1.4)		
Total distances at 7.0–12.9 km.h^{-1} (m)	PP-SSG	289 ± 45.2	258 ± 49.3	249 ± 52.1	256 ± 46.7	0.007	Bout 1 > Bout 3** Bout 1 > Bout 4*
	MG-SSG	210 ± 39.9	179 ± 33.9	163 ± 32.3	168 ± 36.0	0.002	Bout 1 > Bout 3** Bout 1 > Bout 4*
p-value (time x group) (ES)		< 0.001 (1.8)	< 0.001 (1.9)	< 0.001 (2)	< 0.001 (2.1)		
Total distances at 13.0–17.9 km.h^{-1} (m)	PP-SSG	62.1 ± 18.9	67.5 ± 33.3	49.9 ± 27.5	58.1 ± 12.3	0.077	
	MG-SSG	53.2 ± 13.3	50.4 ± 20.5	42.0 ± 14.8	43.3 ± 13.9	0.188	
p-value (time x group) (ES)		0.152 (0.5)	0.108 (0.6)	0.347 (0.4)	0.004 (1.1)		
Total distances at ≥ 18.0 km.h^{-1}(m)	PP-SSG	1.8 ± 3.0	6.5 ± 6.6	2.0 ± 2.3	6.1 ± 8.2	0.170	
	MG-SSG	5.8 ± 9.2	8.8 ± 7.6	9.1 ± 8.1	9.2 ± 10.6	0.356	
p-value (time x group) (ES)		0.105 (0.6)	0.374 (0.3)	0.002 (1.2)	0.363 (0.3)		
Total m/min	PP-SSG	133 ± 11.9	128 ± 14.7	125 ± 13.4	128 ± 10.9	0.005	Bout 1 > Bout 3**
	MG-SSG	119 ± 13.0	114 ± 11.4	108 ± 8.7	111 ± 10.3	< 0.001	Bout 1 > Bout 3***
p-value (time x group) (ES)		0.006 (1.1)	0.005 (1.1)	< 0.001 (1.5)	< 0.001 (1.6)		
Total number of accelerations	PP-SSG	231 ± 10.7	232 ± 19.3	233 ± 13.7	233 ± 12.2	0.918	
	MG-SSG	228 ± 12.6	226 ± 13.0	225 ± 12.1	224 ± 15.1	0.833	
p-value (time x group) (ES)		0.586 (0.3)	0.363 (0.4)	0.113 (0.6)	0.079 (0.7)		
Number of accelerations between 1.0–1.4 m.s^{-2}	PP-SSG	36.3 ± 8.6	42.8 ± 11.2	43.1 ± 8.1	46.8 ± 4.6	0.005	Bout 1 < Bout 4**
	MG-SSG	49.1 ± 10.2	52.8 ± 10.9	56.7 ± 10.6	55.0 ± 10.3	0.046	Bout 1 < Bout 3*
p-value (time x group) (ES)		0.001 (1.4)	0.020 (0.9)	< 0.001 (1.4)	0.008 (1.0)		
Number of accelerations between 1.5–1.9 m.s^{-2}	PP-SSG	30.8 ± 9.2	36.9 ± 7.9	36.3 ± 8.8	39.1 ± 6.4	0.017	Bout 1 < Bout 4*
	MG-SSG	39.2 ± 7.0	41.7 ± 6.0	43.3 ± 5.5	40.1 ± 7.2	0.376	
p-value (time x group) (ES)		0.009 (1.0)	0.072 (0.7)	0.015 (0.9)	0.667 (0.1)		
Number of accelerations between 2.0–2.4 m.s^{-2}	PP-SSG	25.7 ± 6.4	27.0 ± 5.6	28.1 ± 6.0	28.5 ± 5.3	0.386	
	MG-SSG	27.3 ± 3.4	29.9 ± 5.0	29.2 ± 5.7	27.7 ± 4.1	0.495	
p-value (time x group) (ES)		0.412 (0.3)	0.155 (0.5)	0.616 (0.2)	0.657 (0.2)		
Number of accelerations ≥ 2.5 m.s^{-2}	PP-SSG	138 ± 19.1	125 ± 20.5	126 ± 13.3	119 ± 9.6	0.019	Bout 1 > Bout 4**
	MG-SSG	113 ± 22.1	101 ± 13.6	96 ± 14.0	101 ± 16.7	0.034	Bout 1 > Bout 3*
p-value (time x group) (ES)		0.002 (1.2)	0.001 (1.4)	< 0.001 (2.2)	0.001 (1.3)		
Total number of decelerations	PP-SSG	231 ± 12.2	229 ± 10.3	228 ± 14.3	232 ± 15.2	0.736	
	MG-SSG	236 ± 14.8	229 ± 13.1	236 ± 14.5	229 ± 19.6	0.273	
p-value (time x group) (ES)		0.316 (0.4)	0.982 (0)	0.149 (0.6)	0.632 (0.2)		
Maximal speed (km.h^{-1})	PP-SSG	18.0 ± 1.5	19.5 ± 2.2	18.2 ± 1.8	19.9 ± 2.7	0.010	Bout 1 < Bout 4*
	MG-SSG	19.2 ± 1.7	20.4 ± 2.0	20.4 ± 2.0	20.3 ± 2.0	0.093	
p-value (time x group) (ES)		0.052 (0.7)	0.226 (0.4)	0.003 (1.2)	0.681 (0.2)		
Average speed (km.h^{-1})	PP-SSG	7.0 ± 0.4	6.8 ± 0.8	6.5 ± 0.6	6.7 ± 0.5	0.002	Bout 1 > Bout 3**
	MG-SSG	6.1 ± 0.6	5.9 ± 0.5	5.5 ± 0.4	5.7 ± 0.5	0.001	Bout 1 > Bout 3**
p-value (time x group) (ES)		< 0.001 (1.8)	< 0.001 (1.3)	< 0.001 (2)	< 0.001 (2)		

PP-SSG = small-sided games with possession play rule; MG-SSG = small-sided games with mini-goals rule; ES = Cohen´s d effect size (between groups); post-hoc: * < 0.05, ** < 0.01 and *** < 0.001.

Physiological and perceptual characteristics

Table 2 shows the comparison of physiological and perceptual responses between the two different formats of SSGs during bout periods. Significant differences (Time × Group) in SmO_2, RPE and 85–89% HRpeak were observed ($p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.05$; respectively, with ES = 0.3–1.6) with values higher in MG-SSG for SmO_2 and 85–89% HRpeak, except in RPE, whose values were lower compared to PP-SSG. No significant differences (Time x Group) in THb or the other HR-related variables were found ($p > 0.05$, ES < 0.4). Statistically significant differences (Group × Time) in RPE for PP-SSG were found ($p \leq 0.001$). No other differences (Group × Time) were observed for both groups. Post hoc analysis indicated significant differences between bouts in each SSG format ($p \leq 0.05$).

Table 3 shows the comparison of physiological responses between two different formats of SSGs during recovery periods. Significant differences (Time x Group) in 75–84% HRpeak (recovery between bouts 3–4) were found ($p \leq 0.05$, with ES = 0.8) with values lower in PP-SSG. No other differences (Time x Group or Group x Time) were observed ($p > 0.05$) in the rest of the variables for both SSG formats.

Time-motion characteristics

The comparison of time-motion characteristics obtained at each of the 4 bouts of the two SSG formats is presented in Table 4. The ANOVA results indicated significant differences (Time x Group) that are shown below. Lower total distance, total distance travelled at 7.0–12.9 km/h, lower total distance travelled at 13.0–17.9 km/h, total m/min, number of accelerations ≥ 2.5 $m.s^{-2}$ and average speed were observed in MG-SSG versus PP-SSG ($p \leq 0.05$, with ES = 0.4–2.2). On the other hand, higher number of accelerations between 1.0–1.4 $m.s^{-2}$, total distance travelled at 0.1–6.9 km/h, total distance travelled at ≥ 18.0 km/h and maximal speed were observed in MG-SSG versus PP-SSG ($p \leq 0.05$, with ES = 0.2–1.8). Ultimately, a higher number of accelerations between 1.5–1.9 $m.s^{-2}$ was observed in MG-SSG compared to PP-SSG in bout 1 and bout 3 ($p \leq 0.01$, with ES = 1 and $p \leq 0.05$, with ES = 0.9; respectively). Statistically significant differences (Group x Time) are shown in Table 4. Post hoc analysis indicated significant differences between bouts in each SSG format ($p \leq 0.05$).

DISCUSSION

This study aimed to compare the acute physiological and neuromuscular responses and time-motion characteristics when modifying the game design (possession play vs. mini-goals) during 4-a-side in amateur senior football players. The results of our study reject our initial hypothesis, as in general terms, the main findings from this study are: (i) 20-m sprint performance was impaired after the PP-SSG protocol, whereas the 5-m sprint performance was impaired after the MG-SSG protocol; (ii) Between-protocol differences were found in SmO_2 and 85–89% HRpeak with higher values for MG-SSG, and the RPE was lower throughout the MG-SSG protocol than during the PP-SSG; (iii) During recovery periods, there is a significant difference in the recovery between bouts 3–4 in 75–84% HRpeak with a higher value for MG-SSG compared to PP-SSG; (iv) As for time-motion characteristics, some changes were observed in terms of total distance, total distance at 7.0–12.9 km/h, total distance at 13.0–17.9 km/h, total m/min, number of accelerations ≥ 2.5 m/s and average speed for higher values in PP-SSG. On the other hand, PP-SSG showed lower values in total distance at 0.1–6.9 km/h, total distance at ≥ 18.0 km/h, number of accelerations between 1.0–1.4 m/s, number of accelerations between 1.5–1.9 m/s and maximal speed compared to MG-SSG.

Physical fitness performance

Although there are theoretical implications for athletic performance, there is a lack of studies about the effects of SSGs on sprinting and jumping in senior amateur players [36, 37]. As far as we know, neuromuscular fatigue has been little analysed in the scope of SSG studies. Focused on the influence of SSGs on sprinting, a previous study reported a lower sprint performance after two SSG formats (3 vs. 3 and 6 vs. 6, both SSGs played with two goalkeepers) [37]. The results were similar to those in our study. However, it is well known that changing variables such as the number of players and goalkeepers affects the response to SSGs [10], so it is very difficult to reach a consensus comparing that study with ours.

Related to the effects of SSGs on jumping performance, the authors have only found a study that examined the influence of SSGs (1 vs. 1 and 3 vs. 3) on lower limb power between bouts (CMJ) and did not reveal differences in the jump height among bouts [36]. Our study is in line with these results (i.e. it did not find differences in the jump height before and after SSG formats) and supports the view that the type of muscular contraction and recruitment might apparently explain the fact that both running and jump capacities were relatively independent [38]. The current study provides some insights into the effects of different SSG formats on lower limb power (sprinting and jumping performance), with worse sprint performance after SSG protocols. More studies are necessary to improve understanding of the neuromuscular fatigue after different SSG protocols.

Physiological and perceptual characteristics

In this context, it is noteworthy that some previous studies have analysed the effect of the game design on physiological and perceptual responses, concluding that the modification of variables such as the game design and the type of the goal influences the intensity of play in SSGs [15, 16, 39]. Nevertheless, few studies have compared the effects of the game design (mini-goals vs. possession play rule) on physiology and perceptual demands of SSGs. Whereas González-Rodenas et al. [9] reported that possession play rule registered higher intensity of play (in terms of HR) than regular goals but not than mini-goals in 4-a-side, other previous work did show that HR responses are higher in PP-SSG than in MG-SSG and SSG with regular goals and goalkeepers [17]. On the other hand, Halouani et al. [15] determined that the small-goals rule induces lower physiological responses in comparison with the stop-ball rule for the 3 game formats analysed (i.e., 2 vs. 2; 3 vs. 3 and 4 vs. 4).

Of note, the aforementioned studies only provided HR-related variables on bout periods (work). The current study adds information about SmO_2, THb and RPE, in addition to HR-related variables, both in bout and recovery periods (work and rest). The results of this study are in line with those of another work [9], as PP-SSG had a similar intensity as MG-SSG (in terms of HR-related variables, SmO_2, THb) over bout and recovery periods. Concerning RPE values, our study showed that RPE was significantly higher in PP-SSG than MG-SSG. An explanation for this is that distractions during exercise (i.e., the small goal) can lower RPE values even when the intensity (i.e., HR) is the same [40]. This distraction could explain the lower RPE values observed in MG-SSG. The authors suggest that between-study differences might be associated with some methodological issues (i.e., game design, number of players, pitch size), and highlight the importance of modifying the number of players as the main variable to increase or decrease the intensity of an SSG [10]. Therefore, the current study confirms the lack of differences (in terms of intensity) between the two game formats (possession play vs. mini-goals), providing information about several parameters of internal load (no only HR-related variables) over bout and recovery periods.

Time-motion characteristics

Regarding time-motion characteristics, there have been many studies that have analysed the effects of SSGs and the modification of their variables over the physical load (external load) [10, 17, 33, 41], with all those works reporting effects on external load. However, there is a lack of studies about the effects of the game design (possession play vs. mini-goals rule) in SSG on parameters of external load. With the focus on studies assessing the game design, a study [17] examined the extent to which changing the game format (possession play vs. regulation goals and goalkeepers vs. mini-goals only) and the number of players (3 vs. 3, 5 vs. 5 and 7 vs. 7) influenced the physical demands of SSGs, reporting that changes both in game format and the number of players affect the players' physical demands (i.e., possession play imposed greater physical demands on players than other formats) in semiprofessional players. Having said that, it is important to remember that when more than one variable is manipulated simultaneously, responses are more difficult to predict because of the different nature and inter-relation of the stimulus [10].

On the other hand, in a study by Halouani et al. [42], who investigated the effects of the SSG with the stop-ball rule compared to the MG-SSG on physical responses, the authors concluded that the effect on external load of the SSG with the stop-ball rule was significantly greater compared to the MG-SSG (i.e., in terms of total distance, player load, sprint distance, acceleration and deceleration) in elite young players. Other previous work (which compared the possession play vs. mini-goals, among other formats and with official matches) found that MG-SSG presented the lowest demands on external load in elite football players [43]. Additionally, Clemente et al. [41] observed that regular games (with mini-goals) resulted in greater total running and sprinting distances per minute than ball possession games. Therefore, the current study provides support and is in line with those studies that report fewer physical demands for MG-SSG in comparison with other formats (especially against PP-SSG), and it builds up the available information about the manipulation of variables such as game design in SSGs for amateur football players.

Some limitations of the current study must be addressed. First, the sample size was relatively small, which might limit the generalization of findings. Second, there is a lack of data about the players' technical performance, which might add useful information.

Practical applications

The current study provides support for the inclusion of mini-goals within SSGs (4-a-side) to facilitate the application of the load dynamic throughout the competitive period and its inclusion within a training session. From a practical standpoint, the inclusion of mini-goals within SSGs might be well suited on those days when the trainer wants to maintain a high intensity in training sessions without increasing the training load (in terms of external and internal load), since the intensity is similar compared to PP-SSG (even players perceive less workload, and lower RPE) and the volume is smaller (external load). Overall, the format of 4 vs. 4 (without and with mini-goals) is a very appropriate training task that facilitates the effective development of players' fitness. The modification of game design (without and with mini-goals) allows one to increase or reduce the fatigue induced to elicit adaptations related to physical performance. Therefore, coaches and technical stuff might find this research very useful, and the findings should be taken into account when designing and periodizing SSG training during the competitive season of senior amateur football players.

CONCLUSIONS

In summary, this research improves the understanding of some of the physical, physiological and neuromuscular responses affecting SSG intensity when using ball possession or mini-goals. The inclusion of mini-goals during SSG did not cause reductions in the internal load (physiological responses) in amateur football players as compared to possession play SSG. However, the inclusion of mini-goals altered the external load (physical demands), leading to lower values in time-motion characteristics (i.e., in terms of total distances, total m/min, number of accelerations at high speed and average speed). Ultimately, both SSG protocols impaired neuromuscular performance in terms of sprint performance.

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Declaration of interest

The authors report no conflicts of interest.

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