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EFFECTS OF SMALL-SIDED SOCCER GAMES ON INTERNAL AND EXTERNAL LOAD AND LOWER LIMB POWER: A PILOT STUDY IN COLLEGIATE PLAYERS

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ABSTRACT
Purpose. The aim of the study was to examine the influence of small-sided and conditioned games (SSG) on the internal load (heart rate [HR] and perceived exertion), external load (Global Positioning System variables), and lower limb power (squat jump [SJ] and countermovement jump [CMJ]).
Methods. Six collegiate male soccer players (age 20.3 ± 4.8 years; maximal oxygen uptake 42.9 ± 2.7 ml/kg/min; maximal HR 184.7 bpm) performed three 2-min bouts of 1 vs. 1 and two 3-min bouts of 3 vs. 3 format with a work-to-rest ratio of 1:1.5. Two-way ANOVA with repeated measures tested the effects of bouts and SSG formats on the internal and external load and on the lower limb power.
Results. The 3rd bout had significantly higher HRaverage and %HRmax values than the 2nd bout ($p = 0.027$ and $p = 0.026$, respectively). The 1st SSG bout presented higher total distance than the 2nd bout ($p = 0.007$). The comparison among bouts revealed higher values of pace and player load intensity in the 1st bout than in the 2nd one ($p = 0.015$ and $p = 0.019$, respectively). No differences were found in SJ and CMJ among bouts ($p = 0.981$ and $p = 0.307$, respectively). SSG formats differed for total distance ($p = 0.001$; $ES = 0.891$; longer distance in 3 vs. 3 format), but not for %HRmax ($p = 0.953$; $ES = 0.001$).
Conclusions. Physiological and physical responses varied during bouts. Nevertheless, small differences between SSG formats were found. SSG bouts did not have significant impact on the lower limb power.
Key words: football, GPS, training load, neuromuscular fatigue, small-sided games, SSG

Introduction

Small-sided games (SSGs) are very popular training tasks that have been extensively used in the training of soccer players [1]. SSGs are smaller and modified versions of the official game and aim to simulate the dynamics of the match [2]. These games are very popular across the world, mainly because they allow a good commitment to be ensured between physiological/physical stimulus and technical/tactical performance [3]. Some studies have suggested similar acute effects between traditional running activities (e.g. high-intensity interval training) and SSGs [4–6]. Moreover, long-term adaptations after specific training programs based on traditional running activities and SSGs have also shown similar improvements in both methods [7, 8]. For these reasons, the similarity between running activities and SSGs has led to a preference of the the latter owing to their specificity for soccer training [9].

Investigations into SSGs have progressively increased in the last decade [9–12]. The effects of different tasks conditions (e.g. size of the field, format of play, number of ball touches, changing of rules) on physiological and physical variables have been extensively reported [11, 13–15]. The main evidence suggested a greater physiological impact during smaller formats of SSGs (1 vs. 1 to 3 vs. 3) [9, 16, 17]. Heart rate (HR) responses to exercise, rate of perceived exertion (RPE), and blood lactate concentrations were the most common variables in the physiological analyses [2]. It was also observed that smaller formats involved shorter total distance covered but higher playing speed in the external load [18]. Generally, Global Positioning System (GPS) trackers have been used in real-time monitoring of physical load induced by SSGs [19, 20].

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Acute physiological and physical responses to different SSGs have been monitored and reported [2, 9, 16]. Although a few studies analysed the effects of training regimen [21–23], the majority of research conducted on this topic referred to the variance of acute physiological and time-motion variables in intermittent and continuous regimens [21, 24]. Nevertheless, little information was available about the effects of SSG bouts on neuromuscular fatigue during intermittent regimens. In a novel study on team sport players that tested the capacity to perform jumps between repeated sprints, it was suggested that repeated sprint and jump abilities could be considered as different and specific qualities, on the basis on the small correlations between both exercises [25]. However, in a study conducted on male collegiate athletes, squat jumps (SJ) and countermovement jumps (CMJ) were used to test the sensitivity to neuromuscular fatigue, and were found to incorporate a considerable eccentric component (CMJ) that might provide superior sensitivity to neuromuscular fatigue [26].

The neuromuscular fatigue induced by high-intensity actions might lead to a higher risk of injuries [27]. Although the internal and external load has been analysed in the abovementioned studies on SSGs, no information about the neuromuscular effects has been provided, as far as we know. The measure of fatigue impact would improve the knowledge about the acute effects of SSGs and the correct way to control the time of exertion. This could help coaches to test the real neuromuscular consequences of these games. To the best of our knowledge, the present study is the first to test the effects of SSG bouts on neuromuscular fatigue. Therefore, the purpose was twofold: 1) to test the effects of three SSG bouts on SJ and CMJ performance; and 2) to test the variance of internal and external load in two SSG formats with three bouts. We hypothesized that smaller jumps would be made in the last bouts of SSGs. For the second aim, we hypothesized that the smaller format would increase the internal load and the bigger format would raise the external load.

Material and methods

Experimental approach

The participants were monitored during two different SSGs: 1 vs. 1 and 3 vs. 3. Three 2-min bouts in 1 vs. 1 and three 3-min ones in 3 vs. 3 format were performed, with a work-to-rest ratio of 1:1.5. A 15-min rest was conceded between the formats. Both formats were used on the basis of the information that 1 vs. 1 constituted a high-demanding exercise and 3 vs. 3 could be a format more adjusted to threshold workout [16]. The testing session on the first day started with 1 vs. 1 format and was followed by the exact opposite sequence on the second day of data collection. An individual playing area of ca. 75 m^2 was ensured in both formats. The medium size measure for both games was justified in previous studies [17]. The 1 vs. 1 format took place in a field of 10 × 15 m with small goals of 2 m. The 3 vs. 3 format was played in a field of 19 × 24 m with small goals of 2 m. The games were performed on an artificial soccer turf. The games were played without referees but with verbal encouragement. Some rule modifications were adopted, namely no offside and ball reposition with foot. Two extra soccer balls were always available near the goals and at the side of the field to facilitate a quick restart. The games were played in September (early season of 2016/2017) during the period of 10:00–12:00 a.m., with an ambient temperature of 22–24°C and humidity of 60–62%. Internal (HR responses) and external (based on a GPS tracker) loads were monitored during SSGs. RPE and lower limb power were assessed before the study and between the bouts. The comparison of performance variables between bouts and SSG formats was assessed with a repeated measures test.

Participants

Six collegiate male soccer players (20.33 ± 4.83 years old) representing different soccer clubs participated in the study (Table 1). A minimum of 6 years of experience in football was required to take part. All the participants were registered with local football clubs and participated in 2–3 weekly training sessions of 1.30–1.50 hours, as well as one official match at the weekend. Prior to the study, they had undergone a 2-month training. They were all familiar with SSGs and had frequently been exposed to such formats in soccer training sessions. All participants were informed about the experimental protocol and voluntarily signed the informed consent form. The experiments followed the standards of the Declaration of Helsinki for human research.

Procedures of data collection and assessment

The fatigue effect of the bouts was tested with internal and external variables and also with lower limb power tests. HR and RPE were monitored during SSGs. The

Table 1. The participants' characteristics (*M* ± *SD*)

	Age (years)	Height (cm)	Weight (kg)	YYIRT-L1 (m)	VO_2max (ml/kg/min^{-1})	HRmax (bpm^{-1})
M ± *SD*	20.3 ± 4.8	175.217 ± 7.5	69.3 ± 13.0	766.7 ± 318.0	42.985 ± 2.7	184.7 ± 6.1

YYIRT-L1 – Yo-Yo Intermittent Recovery Test Level 1

external load was observed with a GPS tracking system. The neuromuscular fatigue between bouts was tested with SJ and CMJ tests. The cardiorespiratory levels of players were assessed during the Yo-Yo Intermittent Recovery Test Level 1 (YYIRT-L1) in the preceding week, in the afternoon, with the temperature of 22°C.

The height of the participants was measured with a stadiometer of ± 1 cm accuracy (SECA 217, Germany). Body composition was analysed whit multi-frequency bioelectrical impedance (Tanita BC-418, Tanita Corp., Tokyo, Japan). The YYIRT-L1 tested the cardiorespiratory levels of the participants [28]. The test consists of 20-m runs repeated twice, back and forward between the starting, turning, and finishing lines; the increasing speed is controlled by audio bleeps [29]. The test was performed in groups of 3 participants. The HR was monitored with a test employing a Polar H7 Bluetooth monitor (Polar Electro, OY, Kempele, Finland). The highest HR measured during the test was considered the HRmax of the player [29]. The VO_2max of each player was estimated on the basis of the YYIRT-L1, with the formula proposed by the authors of the test [28, 30].

Internal load

RPE (CR-10 Borg's scale) [31] was assessed before the study and between the SSG bouts. At the end of each bout, the players were asked to rate the perceived exertion of the game. They had been familiarized with the RPE protocol in the preceding week in a theoretical session.

HRs were collected in the Polar Team app software with the use of the Polar H7 Bluetooth monitor (Polar Electro, OY, Kempele, Finland), which enabled real-time exercise intensity checking during the SSGs. Two variables were collected during SSGs: HRaverage (bpm) and %HRmax (average during the SSGs).

External load

External load was measured by a motion tracker (JOHAN Sports, Noordwijk, the Netherlands) consisting of a GPS sensor (10 Hz, including EGNOS correction), accelerometer, gyroscope, and magnetometer (100 Hz, 3 axes, ± 16 g). The GPS sensor, measuring at 10 Hz, appears to be valid and reliable to measure position and speed in a sports setting [32]. The GPS sensor used in the study was tested with a 2.5 ± 0,41% (error ± deviation) reliability for the total distance covered.

The players received the motion trackers before the warm-up to get familiarized. The weather conditions during the two testing days were optimal (bright air, open field), which maximized the GPS reception. The motion trackers were worn in a body tight vest to ensure valid (e.g. body oriented) accelerometer data. Motion data from the trackers were uploaded post-experimentally to the JOHAN Sports online analysis platform. Here, the SSGs were defined, the statistics for the parameters were calculated, and GPS data were manually checked for measurement errors.

The GPS sensor measured the total distance, walking distance (0–6,9 km/h), jogging distance (7–13,9 km/h), running distance (14–20 km/h), sprint distance (> 20 km/h), and maximum speed. No individualized speed thresholds were used in the study. The accelerometer was applied to calculate PlayerloadTM. This parameter is an accumulation of data collected from all axes (anteroposterior, mediolateral and craniocaudal).

Squat and countermovement jumps

The power output of leg extensor muscles was assessed through vertical jump tests involving SJ and CMJ. A contact platform (Chronojump-Boscosystem, Spain) was linked with a personal computer with the Chronopic microcontroller that recorded all data from jump tests in the Chronojump software (version 1.6.2 for Windows) [33]. Before testing, the athletes were instructed on the test procedures and requirements [34]. Two trials were conceded prior to the study for each player to guarantee the proper technique of jumping. After a 15-min standardised warm-up according to soccer specifications, all subjects performed the SJs and the CMJs. Two attempts were assessed with a 20-second rest interval between each trial. The data collection took place before the study beginning and at the end of the two different SSGs, in the rest time of each bout in each SSG. The SJ athletes maintained a static position with a 90° knee flexion for 2 seconds before each jump attempt, without any preparatory movement, and kept their hands on their hips. The procedure for the CMJ was similar but instead of the static position at 90°, the athlete stood upright, then squatted down until the knees were bent at 90°, and immediately jumped vertically as high as possible, landing back on the mat. If the procedures and requirements for the jumps were not fulfilled, the athlete repeated the test.

Statistical procedures

The internal (HRaverage and %HRmax) and external (total distance, walking distance, jogging distance, running distance, sprint distance, player load [volume], number of sprints, maximal speed, pace, and player load intensity) variables over the 3 bouts for the 1 vs. 1 and 3 vs. 3 SSGs were calculated. The RPE, SJ and CMJ were compared before the SSGs and between the bouts. The differences among SSGs and among the bouts were compared with the use of 2-way ANOVA with repeated measures. Bonferroni post-hoc test was applied to make a pairwise comparison among different bouts. The partial eta squared tested the effect size (*ES*). The Ferguson's classification for the *ES* was used as follows [35]: no effect

(*ES* < 0.04), minimum effect (0.04 ≤ *ES* < 0.25), moderate effect (0.25 ≤ *ES* < 0.64), and strong effect (*ES* ≥ 0.64). All statistical analyses were carried out with SPSS statistical analysis software (SPSS, version 23.0, Chicago, USA). The level of statistical significance was set at $p \leq 0.05$.

Results

Internal and external load between bouts and formats of the game

Table 2 shows the HR variables (HRaverage and %HRmax achieved in the game) in the three bouts. Statistically significant differences in HRaverage were found between bouts ($p = 0.026$; $ES = 0.306$) but there was no interaction with SSG ($p = 0.084$; $ES = 0.220$, minimum effect). No significant differences in HRaverage were observed between SSG formats ($p = 0.960$; $ES = 0.001$, no effect). The 3rd bout had significantly higher values of HRaverage than the 2nd bout ($p = 0.027$). Statistically significant differences were revealed in %HRmax between bouts ($p = 0.024$; $ES = 0.313$) but there was no interaction with SSG ($p = 0.087$; $ES = 0.217$, minimum effect). No significant differences in %HRmax were observed between SSG formats ($p = 0.953$; $ES = 0.001$, no effect). The 3rd bout had significantly higher values of %HRmax than the 2nd bout ($p = 0.026$).

Table 3 presents the external load variables measured by the GPS tracker in the three bouts of SSGs. Statistically significant differences in total distance were found between bouts ($p = 0.003$; $ES = 0.448$, moderate effect) but there was no interaction with SSG formats ($p = 0.512$; $ES = 0.065$, minimum effect). Significant differences between SSG formats were observed ($p = 0.001$; $ES = 0.891$, strong effect) with a higher value of total distance in the 3 vs. 3 format. The 1st bout of SSGs had significantly higher total distance than the 2nd bout ($p = 0.007$).

Statistically significant differences in walking distance were found between bouts ($p = 0.042$; $ES = 0.271$) but there was no interaction with SSG formats ($p = 0.140$; $ES = 0.179$, minimum effect). Significant differences in walking distance were observed between SSG formats ($p = 0.001$; $ES = 0.928$, strong effect) with greater values covered in 3 vs. 3.

Statistically significant differences in jogging distance were found between bouts ($p = 0.026$; $ES = 0.307$, moderate effect) but there was no interaction with SSG formats ($p = 0.851$; $ES = 0.016$, no effect). Significant differences in jogging distance were observed between SSG formats ($p = 0.013$; $ES = 0.476$, moderate effect) with greater values covered in 3 vs. 3.

No significant differences in running distance were found between bouts ($p = 0.111$; $ES = 0.197$, minimum effect) or in the interaction with SSG formats ($p = 0.260$; $ES = 0.126$, minimum effect). Significant differences of running distance were observed between SSG formats ($p = 0.010$; $ES = 0.499$, moderate effect) with higher running distance covered in the 3 vs. 3 format. A comparison between bouts revealed significantly greater running activity in 1st bout than in 3rd bout ($p = 0.019$).

No significant differences in sprint distance were found between bouts ($p = 0.621$; $ES = 0.047$, minimum effect) or in the interaction with SSG formats ($p = 0.729$;

Table 2. Descriptive statistics (*M* ± *SD*) of HR variables in the different bouts of SSGs

	1 vs. 1 (1st bout)	1 vs. 1 (2nd bout)	1 vs. 1 (3rd bout)	3 vs. 3 (1st bout)	3 vs. 3 (2nd bout)	3 vs. 3 (3rd bout)
HRaverage (bpm^{-1})	171.0 ± 15.0	174.217 ± 11.3*	177.3 ± 11.3*	174.217 ± 12.7	172.3 ± 9.9**	175.0 ± 7.6**
HRmax (%)	92.548 ± 5.3	94.325 ± 4.7*	93.030 ± 12.8*	94.325 ± 4.7	93.3 ± 3.4	94.877 ± 2.5

* significant differences at $p < 0.05$ in 1 vs. 1 format, ** significant differences at $p < 0.05$ in 3 vs. 3 format
HRaverage – average heart rate, HRmax – maximum heart rate

Table 3. Descriptive statistics (*M* ± *SD*) of external load in the different bouts of SSGs

	1 vs. 1 (1st bout)	1 vs. 1 (2nd bout)	1 vs. 1 (3rd bout)	3 vs. 3 (1st bout)	3 vs. 3 (2nd bout)	3 vs. 3 (3rd bout)
Total distance (m)	240.438 ± 15.4	218.8 ± 22.1	227.2 ± 23.8	456.217 ± 51.2	420.0 ± 55.6	427.498 ± 60.2
Walking (0–6.9 km/h) (m)	91.0 ± 6.0	102.107 ± 10.7	93.0298 ± 12.8	189.325 ± 22.5	196.877 ± 21.1	202.1 ± 21.6
Jogging (7–13.9 km/h) (m)	127.1 ± 13.0	102.2 ± 25.2	115.105 ± 33.3	205.217 ± 61.2	168.987 ± 54.7	184.9 ± 63.6
Running (14–19.9) (m)	22.107 ± 18.4	14.5 ± 9.2	18.875 ± 8.9	59.548 ± 23.2	48.5 ± 29.5	37.1 ± 23.8
Sprint (> 20 km/h) (m)	0.2 ± 0.5	0.217 ± 0.4	0.4 ± 0.8	2.325 ± 4.4	1.0 ± 0.9	3.435 ± 5.9
Player load (volume)	16.6 ± 1.6	15.2 ± 2.3	16.1 ± 3.4	27.655 ± 4.7	24.8 ± 5.3	25.0 ± 5.4
Number of sprints	0.217 ± 0.4	0.217 ± 0.4	0.3 ± 0.5	1.0 ± 1.6	1.0 ± 0.9	0.767 ± 0.8
Max speed (km/h)	17.768 ± 2.4	18.108 ± 2.1	18.878 ± 1.4	19.768 ± 1.7	21.217 ± 3.1	20.437 ± 2.8
Pace (m/min)	119.2 ± 7.6	110.3 ± 11.1	113.6 ± 11.9	114.0 ± 12.8	105.0 ± 13.9	107.3 ± 15.1
Player load intensity (g/min)	8.2 ± 0.8	7.767 ± 1.1	8.0 ± 1.7	6.988 ± 1.2	6.2 ± 1.3	6.328 ± 1.3

ES = 0.031). No significant differences of sprint were observed between SSG formats (p = 0.061; *ES* = 0.309, moderate effect).

Statistically significant differences in player load (volume) were found between bouts (p = 0.008; *ES* = 0.384) but there was no interaction with SSG formats (p = 0.273; *ES* = 0.122, minimum effect). Significant differences were observed between SSG formats (p = 0.001; *ES* = 0.659, strong effect) with higher values of player load in the 3 vs. 3 format. Significant differences between the 1st and 2nd bouts were found (p = 0.017) with higher values of player load in the 1st bout.

No statistically significant differences in the number of sprints were found between bouts (p = 0.881; *ES* = 0.004, no effect) or in the interaction with SSG formats (p = 0.603; *ES* = 0.033, no effect). Statistically significant differences were observed between SSG formats (p = 0.044; *ES* = 0.346, moderate effect) with higher values in the 3 vs. 3 format.

No statistically significant differences in maximal speed were found between bouts (p = 0.412; *ES* = 0.085, minimum effect) or in the interaction with SSG formats (p = 0.617; *ES* = 0.047, minimum effect). No significant differences were observed between SSG formats (p = 0.052; *ES* = 0.327, moderate effect).

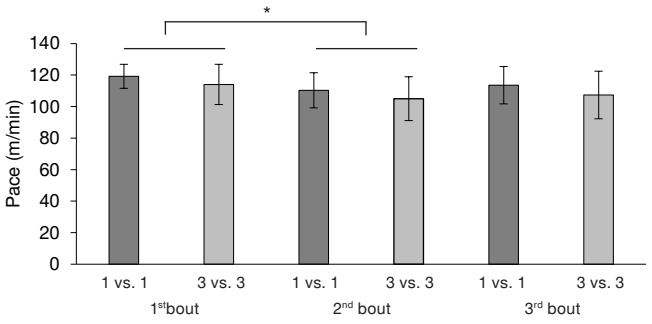
Figure 1 shows the descriptive statistics for the pace variable. Significant differences in pace were found between bouts (p = 0.010; *ES* = 0.368, moderate effect) but there was no interaction with SSG formats (p = 0.975; *ES* = 0.003, no effect). No significant differences were observed between SSG formats (p = 0.402; *ES* = 0.071, minimum effect). A comparison between bouts revealed significantly higher values of pace in the 1st bout than in the 2nd bout (p = 0.015).

Figure 2 presents the descriptive statistics of the player load intensity during the three bouts of SSGs. Significant differences were found between bouts (p = 0.042; *ES* = 0.271, moderate effect) but there was no interaction with SSG formats (p = 0.681; *ES* = 0.038, no effect). No significant differences but moderate effect were observed between SSG formats (p = 0.051; *ES* = 0.329, moderate effect) with greater player load intensity in the 1 vs. 1 format. Overall, significant differences of player load intensity were revealed between the 1st bout and the 2nd bout (p = 0.019).

Influence of bouts and formats in lower limb power tests and perceived exertion

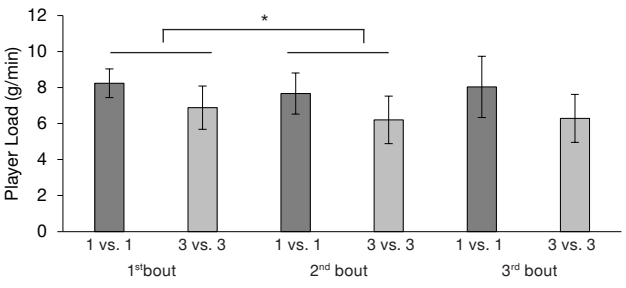
Figure 3 shows the jump height in SJ and CMJ in the four moments (before the bouts and after the 1st, 2nd, and 3rd SSG bouts). In SJ, no significant differences were found between bouts (p = 0.981; *ES* = 0.415, moderate effect) or in the interaction with SSG format (p = 0.119; *ES* = 0.948, strong effect). Also, no significant differences were observed in CMJ between bouts (p = 0.307; *ES* = 0.112, minimum effect) or in the interaction with SSG format (p = 0.153; *ES* = 0.159, minimum effect).

Figure 4 illustrates the RPE scale in the four moments. Significant differences were found between bouts (p = 0.001; *ES* = 0.843) and in the interaction with SSG for-



* significant differences at $p < 0.05$

Figure 1. Mean and *SD* of pace (m/min) in the three bouts of 1 vs. 1 and 3 vs. 3 SSGs



* significant differences at $p < 0.05$

Figure 2. Mean and *SD* of player load intensity (g/min) in the three bouts of 1 vs. 1 and 3 vs. 3 SSGs

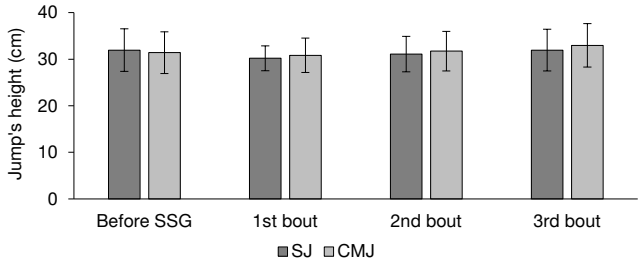
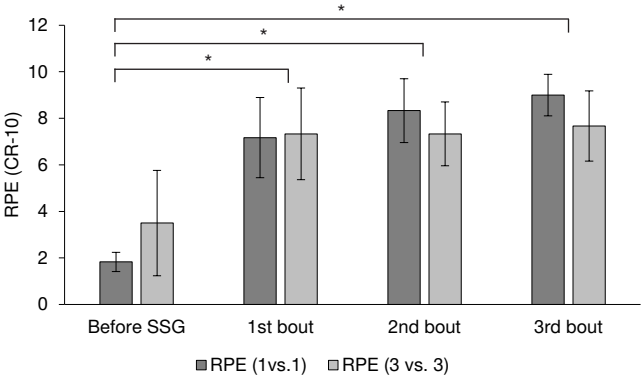


Figure 3. Mean jump's height (cm) in the four studied moments



CR-10 – scale of 10 points, * significant differences at $p < 0.05$

Figure 4. RPE between bouts in the 1 vs. 1 and 3 vs. 3 SSGs

mat (p = 0.046; ES = 0.267, moderate effect). Significant differences were observed in the pairs before SSG and the 1st bout (p = 0.001), before SSG and the 2nd bout (p = 0.001) and before SSG and the 3rd bout (p = 0.001).

Discussion

The purpose of the study was twofold: 1) to analyse the influence of SSG bouts (3 per format of the game) on the internal and external load and also on the lower limb power during jumps; and 2) to analyse the variance of the internal and external load between two different formats of the game (1 vs. 1 and 3 vs. 3).

A main finding concerning the internal load was that the highest HR values were recorded during the last bout. This observation is in line with the results obtained in a study that tested the effects of bout duration in the 3 vs. 3 format [23]. In a study testing 3 SSGs in 4 different periods, also the lowest HR values were revealed in the 1st bout [36]. Nevertheless, in a more recent study such an effect was not found in the 5 vs. 5 format [37]. The increase of HR during the last bout may be justified by the progressive activity of the oxidative system and the proximity of the maximum value [38].

A comparison of HR values did not reveal significant differences between formats. This does not support the general findings comparing the 1 vs. 1 with the 3 vs. 3 formats [39]. The values above 90% HRmax in both formats may justify the absence of differences. The work-to-rest ratio of 1:1 may have contributed to ensuring sufficient recovery between bouts in the 3 vs. 3 format, thus increasing the individual participation and commitment.

No significant differences in RPE were found between formats and bouts. The only significant differences were found between the moment before the 1st bout and the bouts of exercise. This is not in line with previous studies which revealed significant differences between formats [2, 9]. Usually, the extreme 1 vs. 1 format is significantly more intense than the remaining ones [16]. The amateur level of players and the small experience with perceptive scales may explain the results. High athletic experience contributes to a better accuracy in the RPE score [40].

The highest total distance (i.e. external load) was shown in the 1st bout, which was in disagreement with the highest internal load (HR) recorded in the last bout. This indicated that the increased internal load in the 2nd bout, despite the decreased external load, might be attributed to fatigue accumulation from the 1st bout. The higher values of pace and player load intensity in the 1st bout than in the 2nd one were in agreement with the highest total distance shown in the 1st bout. Such findings follow previous studies that compared the distance covered across SSG bouts [37].

Significantly higher values of distance covered and distance covered by walking, jogging, and running were verified in the 3 vs. 3 format. These results can be justified by the greater period of the bout in this format. The normalization of the data made in the cases of pace and player load intensity revealed no significant differences between formats, although with bigger averages of these variables in the smaller format (1 vs. 1). Greater physical intensity in smaller formats were revealed in previous studies [14, 41].

The statistical analysis exposed differences in the pace (m/min) and player load (g/min) between bouts. The 1st bout induced significantly higher values of pace and player load intensity. The absence of fatigue may justify a higher individual participation and activity in the initial bout. Moreover, such intensity in the 1st bout may have contributed to the increase of HR in the last bouts.

As far we know, neuromuscular fatigue has not been analysed in the scope of SSG studies. A unique study was conducted in rugby SSGs and analysed the effects of physical contact on muscle damage, estimated by creatine kinase [42]. Our study used SJ and CMJ to assess the neuromuscular fatigue of lower limb power between bouts. The analysis of variance did not reveal differences in the jump's height among bouts. The results were similar to those in a study that employed a repeated sprint ability protocol and the SJ and CMJ between bouts [25]. The type of muscular contraction and recruitment might apparently explain the fact that both running and jump capacities were relatively independent [25]. Nevertheless, the inexperience of the participants to perform the jumps in the present study might have constrained the results.

A limitation of the present study findings was the small number of participants, which was justified by the pilot nature of the research. A strength of the study was that it used three measures of internal load (HR, RPE, and neuromuscular fatigue) and one measure of external load (GPS), which provided a full description of the exercise load during the two SSG formats. Since SSGs have been extensively applied in soccer training, the findings of the study are of great practical importance for coaches and fitness trainers. Coaches may use this information to adjust the time of workout and prescribe the method. Smaller formats should have smaller periods of workout and greater work-to-rest ratios than bigger ones. Bigger formats may be longer and contribute to lactate threshold workout. Despite these possible practical implications, future studies should be performed to analyse the neuromuscular effect of different SSGs and to perceive the medium-term impact in a 48-hour observation after the games.

Conclusions

The results of the study showed that the 3rd bout increased HR responses and induced higher perception of effort than the 1st and 2nd bouts. Moreover, the higher pace and player load intensity occurred in the 1st bout.

This could suggest a fatigue effect over the bouts. Nevertheless, the indications of the physiological and physical parameters were not confirmed by the neuromuscular output tested with SJ and CMJ between bouts. Comparisons between SSG formats were also assessed in the study. No significant differences of HR responses were found between the 1 vs. 1 and the 3 vs. 3 formats. Significantly greater values of total distance, walking, running, and jogging distances were observed in the 3 vs. 3 format. However, the relative values of pace and player load intensity revealed no differences between formats.

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