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ORIGINAL ARTICLE

Manipulation of number of players and bouts duration in small-sided games in youth soccer players

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Abstract

Purpose To examine the influence of player number, bout duration and their interaction on small-sided game (SSG) variations in running performance, perceptual response and technical components in under-14 soccer players.

Methods Eleven players randomly performed 3v3 and 5v5 SSG of 4 × 5 min, 2 × 10 min and 20 min duration. Total distance (TD), distance covered at high-intensity running (HIR), sprinting and > 80% peak speed of the Carminatti's test ($PS_{T\text{-}CAR}$) were analyzed every 5-min epoch. Rating of perceived exertion (RPE) and players' technical performance were also assessed.

Results TD ($p < 0.001$) and distance > 80% $PS_{T\text{-}CAR}$ ($p = 0.017$) were significantly greater in 4 × 5 min than in the other conditions. The distance covered > 80% $PS_{T\text{-}CAR}$ was significantly ($p = 0.026$) reduced from the 1st and 2nd to the 4th quarter ($\Delta = -34\%$ and -23%, respectively) during the 3v3, while no decrement was found in the 5v5. A downward trend over time was observed for TD ($p = 0.088$), HIR ($p = 0.060$) and sprinting ($p = 0.085$). Players covered more distance > 80% $PS_{T\text{-}CAR}$ during the 3v3 first quarter ($p = 0.009$). RPE was affected by player number and bout duration ($p < 0.0001$), with higher RPE during 3v3 and 1 × 20 min conditions. Significantly more successful passes, contacts with the ball, ball involvement, goals scored and shots on target were achieved during 3v3.

Conclusions Shorter bout duration elicited greater TD and distance > 80% $PS_{T\text{-}CAR}$. A combined influence of player number and period of the game on high-intensity activities was evident. The RPE was significantly influenced by the player number and bout duration. The 5v5 elicited less successful technical outcomes. The 3v3 may be useful for work-rate enhancement and integrated training.

Keywords Youth soccer · Training load · Football · Small-sided games

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Introduction

With the increased soccer match physical demand and constant changes on game-specific technical-tactical requirements over the years [1, 2], different soccer training proposals have emerged to prepare the players to face the high demand of soccer matches. Among the various training possibilities to be implemented in soccer, small-sided games (SSGs) have increasingly become a useful and effective tool used periodically by physical conditioning professionals and coaches aiming to enhance technical-tactical skills along with soccer-specific physical fitness qualities in an integrated way [3]. In a practical setting, SSGs have been incorporated in different ways in the training process, serving as a warm-up strategy within daily training routine [4, 5] or even as an integrated training method to increase the physical performance of the players [6]. In a recent systematic review,

Sarmento et al. [3] reported that the structure and organization of SSGs can be manipulated by modifying several key factors, such as player number, dimensions of the pitch, coach encouragement, game duration and rule modifications.

Assessing the acute effects of player number [7–10] and length of bout duration [11–17] on SSG drills' running performance (distance covered in different speed thresholds), physiological, perceptual and technical-tactical components is among the most prevalent topic in soccer research. It is well established that lower number of players (1v1–4v4) significantly increases the physiological demands [i.e., heart rate (HR), lactate concentration [La], rate of perceived exertion (RPE)] and the number of technical actions performed per player compared to medium- or large-sided games [7–9]. Additionally, the external and internal workload during the different SSG formats are also thought to be influenced by length of bout duration (i.e., continuous or intermittent) [11–17]. The body of information available in the scientific literature has provided controversial findings on this topic. Some studies have reported meaningful differences between different lengths of bout duration on running performance metrics (e.g., total distance covered, high-intensity running and sprint), [La] and RPE values in youth and adult soccer players [11–13, 16, 17]. On the other hand, other studies have demonstrated no significant influence of bout duration on physiological and technical parameters during SSGs [14, 15]. These controversial results could be attributed to a myriad of factors that differed among the aforementioned studies (e.g., adults vs. adolescents, different absolute speed thresholds, different player number and pitch area).

Despite of physiological changes induced by the manipulation of player number and bout duration have been extensively examined in soccer [7–9, 11–17], no study has examined the combined impact (i.e., interaction effect) of these two components (player number and length of bout duration) on external (e.g., high-intensity running distances) and internal (e.g., RPE) load and technical performance measures during SSG in adolescent soccer players. Beyond that, most of these studies have used bouts duration varying between 2 and 12 min [11, 12, 14–16], with few exceptions investigating the impact of bout duration longer than 16 min [13, 17]. Thus, it is recommended to coaches and sports scientists exploring in the future studies the effects of longer bouts duration (> 16 min) using different SSG formats (3v3 vs 5v5) in youth players, as these formats are anecdotally known to be implemented in some periods of soccer preparation.

The majority of available literature on this topic has been conducted with adults [8, 9, 13, 14, 16, 17], and to a lesser proportion, with adolescents between 15- and 17-year-old soccer players [11, 12, 15]. Unfortunately, studies with young players in the initial competitive age categories, such as under-14, are still under-explored. According to the current long-term football player development models [18], the training focus during early and mid- pubertal period should be primarily based on the development and refinement of the technical-tactical skills and players' decision-making abilities [18]. It highlights that SSG method can be even more relevant in these initial ages than in older ages. Players during early and mid-pubertal periods have different metabolic and neuromuscular features compared to their older teammates and adult players, making younger players respond differently to the training stimulus [19]. In addition, age-related variation in team tactical behavior may exist [20–22]. Recent investigations have shown that age groups deal differently with the available space, showing different positioning behavior on the pitch [20–22]. These age-related differences can support the interest in examining the impact of different SSG formats with distinct lengths of bout duration in players aged under-14. This knowledge can provide useful information to coaches about what type of SSG induces higher physical demand and perceptual responses in these players of initial competitive ages.

Therefore, the present study aimed to evaluate the influence of player number, length of bout duration, and their interaction in SSG variations on running performance metrics, perceptual response and technical components in male under-14 soccer players. It was hypothesized that running performance and perceptual response would be dependent on the amount of player's number and length of bout duration, while technical measures would not be influenced by the interaction between these two independent variables.

Methods

Participants

Eleven male youth soccer players (mean ± SD: age 13.0 ± 0.8 years, weight 52.5 ± 9.3 kg, height 155.8 ± 16.0 cm, final speed reached during Carminatti's test: 14.91 ± 1.0 km h^{-1}) took part of this study. All the players were recruited from an under-14 age category belonging to a soccer professional club registered in Brazilian National Soccer Confederation (CBF). At the time of study, all the participants took part in three to four 90–120 min of training sessions per week, in addition to a competitive match. Coaches, players, parents or tutors were informed of the research procedures, requirements, benefits, and risks before giving written informed consent (parents) and assent (players). Participation was voluntary and players could withdraw at any time without any penalty. This study was approved by the Research Ethics Committee of the local university (46455015.3.0000.0121).

Carminatti's test (T-CAR)

The Carminatti's test (T-CAR) was performed during the pre-season phase in the week immediately prior to the application of the first SSG format. The test consisted of intermittent shuttle runs of 12 s performed between 2 lines set at progressive distances with a 6-s recovery between each run and a total stage time of 90 s. The protocol had a starting velocity of 9 km h^{-1} over a running distance of 30 m (15 m back and forth). The length in a single direction was increased progressively by 1 m at every level. Each stage consisted of 5 repetitions with a 6 s walking period between 2 lines set 2.5 m from the starting line. Eight to 10 athletes were evaluated simultaneously with the running pace dictated by a pre-recorded audio system [23, 24]. The test ended when participants failed to follow the audio cues on the front line for 2 successive repetitions (objective criteria observed by researchers). The last stage speed ($PS_{T\text{-}CAR}$) during the T-CAR was retained to allow the individualization of the distance covered during the different SSG formats and bout duration conditions outlined here.

Small-sided games (SSG)

All SSG formats were carried out on Monday (match day minus 5) and Wednesday (match day minus 3) within a 4-week period during the pre-season phase. The two SSG formats used in the present study were: (1) 3 players a side and (2) 5 players a side, with goalkeepers in both conditions defending an official soccer goal. The whole duration of each SSG format (3v3 or 5v5) in all cases was 20 min, in which three distinct bout durations were tested: (1) 4 × 5 min [short duration], (2) 2 × 10 min [medium duration] and (3) 1 × 20 min [long duration]. All participants played only once in each SSG format and bout duration condition, resulting in a total number of 66 individual observations (11 players × 2 SSG formats × 3 bout durations = 66 observations [six individual samples for each player]). The rest period between intermittent bouts were 150 s and 300 s for 4 × 5 min and 2 × 10 min, respectively (i.e., 2:1 work-to-rest ratio). The pitch area during the 3v3 and 5v5 games were 37 × 24 m and 48 × 31 m, respectively, to maintain a relative pitch area close to 150 m^2 per player, as well as a length-to-width ratio close to 1.54. The head coach organized the teams according to playing positions, technical-tactical level, playing experience, and players' aerobic fitness [25]. The head coach also provided verbal encouragement and introduced balls immediately when the ball left the playing field.

Rating perceived exertion (RPE)

The CR-10 rating of perceived exertion (RPE) scale proposed by Foster et al. [26] was presented to each player 10–15 min after the last bout of each SSG. All players were informed about, and familiarized with, the CR-10 scale before the study commencement. This scale has been validated as an indicator of internal training intensity in soccer studies [11–13].

Running performance variables

To quantify soccer players' physical demands in each SSG format and bout duration conditions, a global positioning system (GPS) with a resolution of 10 Hz (K-Sport, Montellabate, Italy) was used [27, 28]. The GPS was framed at the top rear of each player's trunk using an adjustable neoprene vest. Data were downloaded post-SSG protocols to a computer and analyzed using a customized software package (Prozone1®, Leeds, England). All running performance metrics derived from GPS data were analyzed every 5-min epoch to provide information about temporal changes throughout SSG formats and bout duration conditions. Total distance (TD) in addition to distance covered in the following arbitrary running speed zones were retained: (1) high-intensity running (HIR): 13.0 ≤ distance covered < 18 km h^{-1}; (2) sprinting: distance covered ≥ 18 km h^{-1} [29]. Using an individualized speed threshold, the distance covered > 80% of peak speed reached at the end of Carminatti's test ($PS_{T\text{-}CAR}$) was also computed for each player during all SSG conditions. This individualized speed threshold was selected based on prior studies showing that 80% $PS_{T\text{-}CAR}$ corresponds to the anaerobic threshold in soccer players [30]. A prior study has recommended using individualized speed thresholds for determining the distance run at high-intensity zone [31].

Technical components analysis

The technical skills specific to soccer were evaluated through the analysis of game footage, as previously described in studies with soccer players [32, 33]. A digital video camera was positioned to frame all four corners of the field to record the technical actions performed by the players during the SSG. In this sense, the following actions were analyzed: total number of successful passes (SP), unsuccessful passes (UP), contacts with the ball (CB), ball involvement (BI), goals scored (GS), shots on target (ST) and unsuccessful shots (US) made per player.

Statistical analysis

Data are presented as mean ± standard deviation or ± 90% confidence intervals (± 90% CI). After visual inspection, the Shapiro–Wilk test was used to test normality. Levene's test was used to test if the homogeneity of variance was assumed. A mixed model analysis for repeated measures,

having SSG formats (3v3 and 5v5), bout duration and period of the game (1st, 2nd, 3rd and 4th quarter) as fixed factors and participants as random factor was performed for running performance metrics. For RPE scores and technical components, the period of the game was not included in the mixed model analysis. In case of significant F-values, a Bonferroni adjustment was implemented for pairwise comparisons. The magnitude of the differences was assessed using standardized mean differences (Cohen effect size, ES) with thresholds of 0.20, 0.60, 1.20, 2.0 and 4.0 for small, moderate, large, very large and extremely large [34]. Statistical analyses were performed in the software SPSS 17.0 and significant p values were set as $p \leq 0.05$.

Results

Table 1 shows the physical and technical variables between considered SSG format, bout duration and periods of the game. The outputs to examine the effects of SSG format, bout duration, periods of the game and the interaction terms on dependent variables are summarized in Table 2.

Running performance

The mean value for $PS_{T\text{-}CAR}$ was 15.06 ± 1.00 km h^{-1}, which means that 80% of $PS_{T\text{-}CAR}$ corresponded to an average speed of 12.11 ± 0.81 km h^{-1}.

Players covered significantly greater TD ($F = 8.014$; $p < 0.001$) and distance > 80% $PS_{T\text{-}CAR}$ ($F = 4.175$; $p = 0.017$) during the 4 × 5 min than in the 2 × 10 min (Δ = 6%, $p = 0.003$, ES = 0.47 [90% CI 0.17–0.77]; Δ = 13%, $p = 0.044$, ES = 0.36 [90% CI 0.05–0.66]) and 1 × 20 min (Δ = 7%, $p = 0.001$, ES = 0.52 [90% CI 0.22–0.83]; Δ = 14%, $p = 0.034$, ES = 0.37 [90% CI 0.06–0.68]) bout duration, respectively. A significant main effect of period of the game was also observed for TD ($F = 13.045$; $p < 0.001$) and HIR ($F = 3.772$; $p = 0.013$). TD and distance traveled in HIR were significantly decreased in the 4th quarter compared to the 1st (Δ = − 13%, $p < 0.001$, ES = − 0.99 [90% CI − 1.40 to − 0.59]; Δ = − 20%, $p = 0.024$, ES = − 0.50 [90% CI − 0.92 to − 0.09]), 2nd (Δ = − 9%, $p < 0.001$, ES = − 0.75 [90% CI − 1.15 to − 0.34]; Δ = − 18%, $p = 0.042$, ES = − 0.48 [90% CI − 0.90 to − 0.05]) and 3rd (Δ = − 7%, $p = 0.007$, ES = − 0.54 [90% CI − 0.94 to − 0.15], for TD) quarters,

Table 1 Descriptive statistics (mean ± DP) for physical (upper portion), perceptual (middle portion) and technical variables (lower portion) with comparisons between SSG format, bout duration and period of the game (only for physical variables)

	SSG format		Bout duration			Period of the game			
	3v3	5v5	4 × 5 min	2 × 10 min	1 × 20 min	1st	2nd	3rd	4th
> 80% $PS_{T\text{-}CAR}$ (m)	124.8 ± 52.9	115.8 ± 42.6	132.0 ± 50.7†	115.0 ± 44.8	113.9 ± 47.2	130.0 ± 57.9	127.5 ± 44.9	119.8 ± 42.6	103.8 ± 42.2
TD (m)	465.8 ± 64.9	456.7 ± 60.4	481.8 ± 64.8†	454.1 ± 52.5	447.8 ± 65.3	489.3 ± 64.4$^{\S+}$	469.0 ± 51.3^{+}	459.4 ± 58.6^{+}	427.1 ± 60.3
HIR (m)	115.0 ± 49.7	111.1 ± 44.4	112.7 ± 50.9	114.1 ± 44.8	112.4 ± 45.8	122.1 ± 52.8^{+}	119.0 ± 46.2^{+}	113.7 ± 41.3	97.5 ± 44.3
Sprint (m)	18.2 ± 16.2	17.3 ± 13.8	19.5 ± 18.0	18.1 ± 14.8	15.7 ± 11.5	15.7 ± 16.6	21.6 ± 15.0	17.0 ± 14.1	16.8 ± 13.9
RPE (a.u.)	6.8 ± 1.5*	4.9 ± 1.5	5.1 ± 1.2††	5.1 ± 1.4††	7.3 ± 1.7	–	–	–	–
SP	22.0 ± 7.2*	15.9 ± 6.3	21.1 ± 8.0	18.4 ± 8.3	17.3 ± 5.2	–	–	–	–
UP	3.6 ± 2.1	3.7 ± 1.8	4.1 ± 2.1	3.8 ± 1.7	3.0 ± 1.9	–	–	–	–
CB	108.5 ± 31.8*	63.0 ± 27.9	94.1 ± 37.8	84.5 ± 44.7	78.5 ± 28.3	–	–	–	–
BI	35.1 ± 8.6*	23.2 ± 6.9	31.7 ± 9.0††	29.6 ± 12.3	26.1 ± 6.8	–	–	–	–
GS	1.6 ± 1.4*	0.6 ± 1.0	0.8 ± 0.9	1.5 ± 1.6	1.0 ± 1.3	–	–	–	–
ST	2.4 ± 1.6*	0.7 ± 1.1	1.7 ± 1.4	1.4 ± 1.9	1.6 ± 1.7	–	–	–	–
US	1.2 ± 1.1	0.8 ± 0.9	1.2 ± 0.8	0.8 ± 1.0	0.9 ± 1.2	–	–	–	–

$PS_{T\text{-}CAR}$ peak speed at the end of Carminatti's test, *TD* total distance, *HIR* high-intensity running, *RPE* rating of perceivedexertion, *SP* successful passes, *UP* unsuccessful passes, *CB* contacts with the ball, *BI* ball involvement, *GS* goals scored, *ST* shots on target, *US* unsuccessful shots, *a.u* arbitrary unit

*Significantly different from 5v5 SSG format

†Significantly different from 2 × 10 min and 1 × 20 min

††Significantly different from 1 × 20 min

$^{+}$Significantly different from the 4th quarter period

§Significantly different from the 3rd quarter period

Table 2 Mixed models outputs to examine the effects of SSG format, bout duration, period of the game and the interaction terms as significant source of intra-individual variability on physical, perceptual and technical variables for the total sample of young soccer players ($n = 11$)

	Main effects			Interaction effects			
	SSG format	Bout duration	Period of the game	SSG format vs bout duration	SSG format vs period of the game	Bout duration vs period of the game	SSG format vs bout duration vs period of the game
	F [*p* value]	*F* [*p* value]	*F* [*p* value]	*F* [*p* value]	*F* [*p* value]	*F* [*p* value]	*F* [*p* value]
> 80% $PS_{T\text{-}CAR}$	2.596 [0.109]	**4.175 [0.017]**	4.716 [0.004]	0.318 [0.278]	**3.202 [0.026]**	0.239 [0.963]	**2.761 [0.017]**
TD	1.735 [0.189]	**8.014 [< 0.001]**	**13.045 [< 0.001]**	0.739 [0479]	2.237 [0.088]	0.976 [0.447]	1.376 [0.236]
HIR	0.484 [0.487]	0.037 [0.964]	**3.772 [0.013]**	0.311 [0.733]	2.546 [0.060]	0.206 [0.974]	2.041 [0.069]
Sprint	0.279 [0.598]	1.745 [0.179]	1.903 [0.136]	0.998 [0.371]	2.291 [0.085]	1.034 [0.410]	1.801 [0.110]
RPE	**44.260 [< 0.001]**	**21.966 [< 0.001]**	–	0.631 [0.539]	–	–	–
SP	**13.541[< 0.001]**	2.016 [0.145]	–	0.974 [0.385]	–	–	–
UP	0.067 [0.797]	1.929 [0.158]	–	1.631[0.208]	–	–	–
CB	**39.788 [< 0.001]**	1.660 [0.204]	–	1.909 [0.162]	–	–	–
BI	**42.401 [< 0.001]**	**4.266 [0.021]**	–	2.103 [0.135]	–	–	–
GS	**13.889 [< 0.001]**	2.021 [0.147]	–	1.514 [0.233]	–	–	–
ST	**23.299 [< 0.001]**	0.226 [0.799]	–	0.284 [0.754]	–	–	–
US	2.143 [0.150]	1.020 [0.373]	–	0.671 [0.519]	–	–	–

Bold values denote significant main and interaction effects

$S_{T\text{-}CAR}$ peak speed at the end of Carminatti's test, *TD* total distance, *HIR* high-intensity running, RPE rating of perceived exertion, *SP* successful passes, *UP* unsuccessful passes, *CB* contacts with the ball, *BI* ball involvement, *GS* goals scored, *ST* shots on target, *US* unsuccessful shots

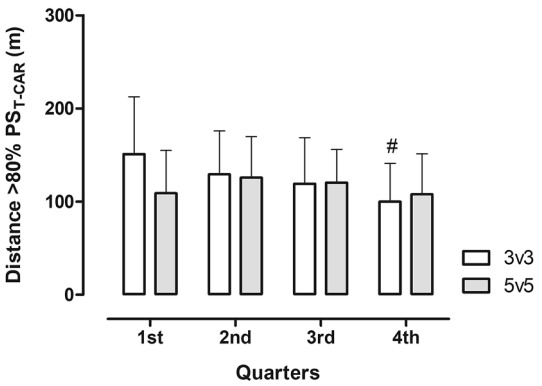

Fig. 1 Distance covered > 80% $PS_{T\text{-}CAR}$ over the various periods of the game within each SSG format. Data are shown as mean ± DP
significantly lower than in the 1st and 2nd quarter during the 3v3 SSG format ($p < 0.05$)

respectively (Table 1). It was found a significant SSG format by period of the game interaction effect ($F = 3.202$; $p = 0.026$) only for the distance > 80% $PS_{T\text{-}CAR}$ (Fig. 1), while a trend towards the significance level was observed for TD, HIR and sprint (Table 2). The distance covered > 80% $PS_{T\text{-}CAR}$ was significantly reduced from the 1st (150.9 ± 61.6 m, $p = 0.001$, ES = 0.97 [90% CI 0.37–1.58]) and 2nd quarters (129.3 ± 46.5 m, $p = 0.050$, ES = 0.67 [90% CI 0.06–1.28]) to the 4th quarter (99.9 ± 41.2 m) during the 3v3 SSG format, while no decrement was found in the 5v5 SSG format (Fig. 1). There was also a significant SSG format by bout duration by period of the game interaction effect ($F = 2.761$; $p = 0.017$) (Fig. 2). During the 1st quarter of the 4 × 5 min bout duration condition, players covered significantly more distance ($p = 0.009$) in the 3v3 than in the 5v5 (174.2 ± 71.1 vs. 100.0 ± 44.3 m, ES = 1.25 [90% CI 0.51–1.99]; respectively) SSG format (Fig. 2). Despite no significance, a similar trend was verified for HIR ($F = 2.041$; $p = 0.069$). The remaining interaction terms were not statistically significant ($p > 0.05$) (Table 2).

Technical variables

For the technical variables, with exception of unsuccessful passes and shots, there was a significant SSG format effect on successful passes ($F = 13.541$; $p = 0.001$), contacts with the ball ($F = 39.778$; $p < 0.001$), ball involvement ($F = 42.401$; $p < 0.001$), goals scored ($F = 13.889$; $p < 0.001$) and shots on target ($F = 23.299$; $p < 0.001$) (Table 2). Significantly more successful passes (ES = 0.90 [90% CI 0.41–1.38]), contacts with the ball (ES = 1.52 [90% CI 1.04–2.01]), ball involvement (ES = 1.53 [90% CI 1.05–1.99]), goals scored (ES = 0.82 [90% CI 0.40–1.34]) and shots on target (ES = 1.24 [90% CI 0.72–1.75]) were reached in 3v3 than in 5v5 SSG format, respectively (Table 1). A significant bout duration effect ($F = 4.266$; $p =$

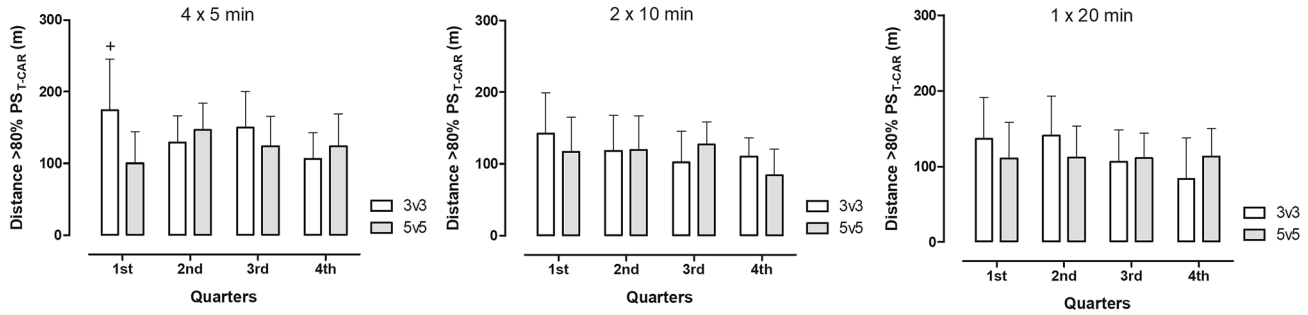

Fig. 2 Distance covered > 80% $PS_{T\text{-}CAR}$ over the various periods of the game within each SSG format and bout duration. Data are shown as mean ± DP

+ denotes significant difference in relation to 5v5 SSG format during the 1st quarter of the short bout duration condition ($p < 0.05$)

0.021) was found only for ball involvement (Table 2). There was significantly more ball involvement in the 4 × 5 min than in the 1 × 20 min bout duration condition (ES = 0.70 [90% CI 0.08–1.32]) (Table 1). The interaction SSG format by bout duration was not a significant source of variation ($p > 0.05$) for any technical variable (Table 2).

RPE score

The mean RPE score was significantly influenced by the SSG format ($F = 44.260$; $p < 0.0001$) and bout duration condition ($F = 21.966$; $p < 0.0001$), while the "SSG format by bout duration" interaction was not significant ($F = 0.631$; $p = 0.539$) (Table 2). Players' perceived effort was significantly greater in 3v3 than in 5v5 SSG format ($p < 0.001$, ES = 1.27 [90% CI 0.92–1.54]). In addition, players perceived their effort as significantly harder during the 1 x 20 min than in the 2 × 10 min ($p < 0.001$, ES = 1.41 [90% CI 0.84–1.89]) and 4 × 5 min ($p < 0.001$, ES = 1.50 [90% CI 0.92–1.97]) bout duration conditions (Table 1).

Discussion

The main purpose of this study was to examine the independent and combined (i.e., interaction) effect of player number and bout duration on running performance, RPE and technical components in male under-14 soccer players. Our main findings were: (1) a combined influence (i.e., interaction effect) of player number, bout duration and period of the game for the distance covered > 80% $PS_{T\text{-}CAR}$, (2) an independent effect of player number and bout duration on RPE, and (3) a main effect of player number for the technical actions. Compared to 5v5 condition, the distance covered > 80% $PS_{T\text{-}CAR}$ was higher during the 1st quarter when playing 3v3 SSG format. In addition, the players covered less distances > 80% $PS_{T\text{-}CAR}$ in the 4th compared to the 1st and 2nd quarter during the 3v3, while no reduction was observed in the 5v5 SSG format. Regardless of player number, players perceived their effort as harder during long (20 min) than in the other bout durations; the RPE was also higher during 3v3 than in the 5v5 SSG format regardless of bout duration conditions. During the 3v3 format, there were more technical actions per players than in the 5v5 SSG format.

This study adds interesting findings and practical information to the current body of evidences available on the topic of SSG in youth soccer players. Moderate decrements of distance covered > 80%$PS_{T\text{-}CAR}$ throughout the 3v3 SSG format were reported ($p = 0.026$), while no change was identified during the 5v5 condition (Fig. 1). The SSG format by bout duration interaction effect was close to significance for TD and other arbitrary speed thresholds such as HIR and sprinting (Table 2). A plausible argument to support this result might be attributed to the higher physical demand observed during the 1st quarter in 3v3 than in 5v5 SSG format (Fig. 2). This temporary decrease in performance suggests that even under-14 young soccer players can display a cumulative fatigue towards the end of SSG formats with fewer players. Differently from this study results, Moreira et al. [35] reported work-rate decrements across quarters during the 5v5 format in older soccer players (14.8 ± 0.2 years). Difference in player's age, criteria used to establish running intensity zones and GPS equipment make between-studies comparisons difficult, warranting further studies to examine whether age may affect SSG responses in youth soccer. Another finding of this study was that shorter bouts (4 × 5 min) elicited higher TD (6–7%) and distance covered > 80% $PS_{T\text{-}CAR}$ (13–14%) than medium and long bout duration. Previous research using arbitrary speed thresholds has also demonstrated greater distance travelled at high-intensity activities when the sets were consisted by shorter instead of medium and long bout duration during time-matched SSG formats [12, 36]. Performing high-speed running has been attributed as crucial to induce physical performance enhancements and to success in soccer [37]. These data highlight the importance and need to incorporate SSG

formats with shorter stimulus when the goal is to optimize high-intensity actions within training practices.

Monitoring of internal training loads by means of session-RPE method has been a common practice in team sports [26, 38], especially in age categories under professional level where the availability of technology devices is scarcer. From this methodology, it is possible to obtain different information related to training load accumulated by the athlete [38]. Among them, the RPE has been used as a global and subjective index of training intensity. In this study, players perceived their effort as harder during long (7.3 ± 1.7 a.u.) than in short (5.1 ± 1.2 a.u.) and medium (5.1 ± 1.4 a.u.) bout duration conditions (Table 1). It should be noted that large differences were noticed between bout duration conditions in our study. This finding is in agreement with previous studies conducted with adolescent soccer players [12, 36]. For instance, Christopher et al. [12] found higher RPE during the continuous 8 min block (4.5 ± 1.5 au) compared to intermittent 2 × 4 min (3.9 ± 1.4 au) and 4 × 2 min (3.3 ± 1.4 au) 6v6 SSG conditions in young soccer players (15.8 ± 0.6 years). In accordance with our findings, Hill-Hass et al. [35] also showed that RPE score was significantly higher in continuous 24 min than in intermittent 4 × 6 min SSGs. More recently, Koklu et al. [11] reported that RPE was substantially greater during continuous SSG condition (1 × 12 min) than in 3 × 4 min and 2 × 6 min bout durations, but similar to short bout duration (6 × 2 min), in different SSGs formats (2v2, 3v3 and 4v4). Hill-Haas et al. [36] stated that one possible reason to explain the greater perceived exertion during continuous (i.e., single) than in intermittent SSGs bouts could be related to the considered rest period allowing for greater recovery [36]. While this hypothetical argument is logical, prior studies have not supported this idea, showing that the manipulation of recovery duration did not interfere the perceptual response during different intermittent SSG formats [39, 40]. However, caution is required to interpret these results since these previously cited studies have not compared the perceptual responses between a single continuous long bout in relation to intermittent bouts with different recovery duration. Another explanation for this finding in our and prior studies may be attributed to the relationship between task duration and perceived exertion [39, 41]. Some studies have shown progressive increases of perceived exertion across serial bouts (i.e., increasing total task duration) during SSG or interval training sessions in team [39] and individual sports athletes [41].

In this study, it was also noticed meaningful differences (large ES) in RPE score between 3v3 (6.8 ± 1.5 a.u) and 5v5 (4.9 ± 1.5 a.u) SSG formats regardless of bout duration condition. In a prior study, Abrantes et al. [42] also found that 3v3 SSG format elicited higher RPE values than 4v4 SSG format. Köklü et al. [11] although not making this comparison in their study, reported a trend of increased RPE values as the number of players decreased. The rationale underpinning these results can be partially attributed to the fact that SSGs with fewer players increases the individual ball possession time, which, in turn, implies higher exercises intensities [43–45] and energy expenditure [46], increasing thus the players' perception of effort. Furthermore, the augmented subjective rating of exertion in 3v3 could be linked to increased distance covered > 80% $PS_{T\text{-}CAR}$ in the 1st quarter of the game, indicating that a higher external training load translated into a greater perceived exertion during SSG with fewer players.

In agreement with prior available studies [7–9, 42], our findings consistently reported that player number was the most influential component in increasing the frequency of technical actions, while the length of bout duration had a negligible effect on most of the technical variables, with exception on ball involvement. During 3v3, players had significantly more successful passes, contacts with the ball, ball involvement, goals scored and shots on target than in 5v5 SSG format. Within a tactical perspective, SSG with fewer players reduces the number of possible passes option and team ball possession imposing greater needs of players to be moving to create passing opportunities leading to an increase in the interaction of each player with the ball [42]. Reducing the number of players may result in an interesting strategy to increase the amount of technical action performed per player and promote a change in playing behavior, and in turn the development of specific technical skills. However, given the technical challenge reported during 5v5 may be advisable to coach the use of this SSG format to improve players' skill when in paradigms closer to real match play. A further novel finding of this study with practical relevance to coaches and technical staffs was the reduced ball involvement per player as bout duration increased during SSGs. This result is a key information to design and create appropriated training drills aiming to develop players' technical skill and decision-making in these initial competitive ages.

Some limitation should be addressed. First, the total sample size of this study was rather small ($n = 11$). This was imposed by the inability to find more players at the same chronological age and training level in the place where the current study was conducted. In addition, for logistical reasons in the weekly schedule of the team that took part of this study, all players played only once in each SSG format and bout duration condition, resulting in a low number of individual observations per player ($n = 6$). Second, neither HRpeak nor RPE were measured during the Carminatti's Test, making it difficult to ensure that all players gave their maximum effort. Third, no information was collected regarding the effect of players' number and drill duration manipulation on tactical metrics. Given the importance of this issue for player development, further studies considering

players of different ages, fitness levels and competitive levels are warranted.

Conclusion and practical applications

Higher distance covered > 80% $PS_{T\text{-}CAR}$ was registered during the 1st quarter of the 3v3 than in the 5v5 SSG format, resulting in a decline of running performance in the 4th quarter compared to the 1st and 2nd quarters during the 3v3 SSG format. In addition, the RPE was higher during SSG with fewer players and longer bout duration. Finally, technical actions performed per players were higher during 3v3, while the ball involvement decreased as SSG duration increased.

If the goal of the training session is to promote a higher internal and external workload and induce some degree of decrement of running performance is recommended to use 3v3 SSG format with short bout duration (4 × 5 min). The development of technical skills should be preferentially achieved using SSG with fewer players. This considering bout duration no longer than 10 min since longer bout duration (1 × 20 min) may reduce players' ball involvement.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict interest.

IRB approval This study was approved by the Research Ethics Committee of the local university (46455015.3.0000.0121) and appropriate standards for human experimentation have been followed.

Informed consent All the participants were informed of the research procedures, requirements, benefits, and risks before giving written informed consent (parents) and assent (players).

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