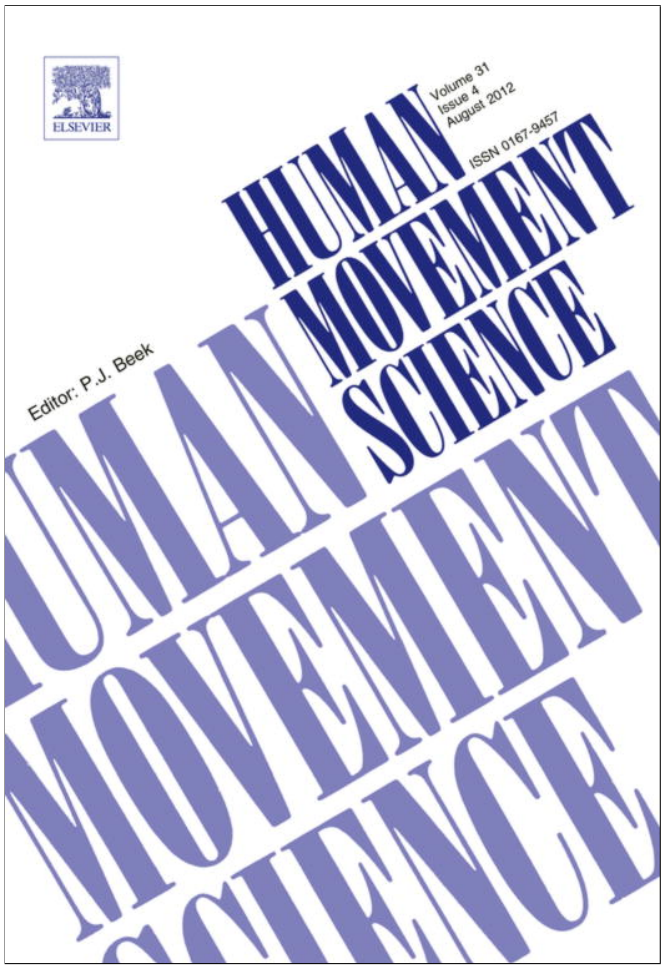

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Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer

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ABSTRACT

The aim of this investigation was to compare the effects of common rule changes on technical and physical demands for elite soccer players in five playing positions during various 4-min small-sided games (SSGs) in comparison to 11-a-side matches. Forty international players classified into five positional roles participated in the study (25.3 ± 2.4 years, 182.4 ± 2.3 cm, 77.3 ± 4.1 kg; M ± SD). Players completed three different conditioned small-sided 4 vs. 4 games (1 ball touch = 1T, 2 ball touches = 2T and Free Play = FP) as well as two friendly matches. Heart rate (HR), blood lactate ([La]), ratings of perceived exertion (RPE) as well as physical and technical performance were analyzed. Compared to match-play, total distance covered per minute of play, high-intensity running activities (sprinting and high-intensity runs), total numbers of duels and lost ball possessions were significantly greater within SSGs for all playing positions ($p < .05$). In contrast, [La], percentage of successful passes and number of ball possessions were lower ($p < .05$) within SSGs, particularly with 1T and 2T rules, in comparison with match-play. HR was higher in SSGs compared to match-play for all playing positions, and RPE values were lower ($p < .05$) during the FP SSG for defensive midfielders, wide midfielders and

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forwards. In conclusion, this study revealed that 4 vs. 4 SSGs played with 1 or 2 ball touches increased the high-intensity running and the difficulty to perform technical actions, being more specific to match demands. Subsequently, it is of importance for coaches to understand the different physiological demands imposed upon players by varying the rules of SSGs and to understand the differences between positional roles.

1. Introduction

Within professional soccer, the use of small-sided games (SSGs) as a means of concurrently developing a player's technical, physical and tactical abilities are well documented (Carling, 2010; Casamichana & Castellano, 2010; Dellal et al., 2011; Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Rampinini et al., 2007; Stolen, Chamari, Castagna, & Wisloff, 2005). The manipulation of pitch size, number of players, verbal encouragement and rule changes within SSGs have been extensively investigated in order to alter the physical load to levels that may elicit physiological match-specific adaptations (Dellal et al., 2008; Hill-Haas et al., 2010; Jones & Drust, 2007; Little & Williams, 2006; Owen, Twist, & Ford, 2004; Rampinini et al., 2007). SSGs with various rule changes have been suggested to be a way of frequently exposing players to situations that they encounter during competitive matches (Jones & Drust, 2007). Players constantly exposed to these situations have been suggested to improve their decision-making, technical skills, tactical knowledge and physical conditioning through functional movements (Owen, Wong, McKenna, & Dellal, 2011; Platt, Maxwell, Horn, Williams, & Reilly, 2001). Furthermore, soccer match-performance has been reported to be dependent on the successful interaction of the technical, tactical and physical aspects of the game (Carling, 2010; Dellal et al., 2008). It would be expected that if one or more of these components can be developed simultaneously (e.g., technical and physical), rather than isolated, coaches would have the opportunity to maximize their contact time with players and increase the efficiency of their training sessions.

Previous research has indicated that in order to optimize the players' match-play performance, training sessions should induce similar physiological and technical demands to that encountered during competition (Dellal, Wong, Moalla, & Chamari, 2010; Dellal et al., 2011). Indeed, position specific requirements vary considerably during match-play as indicated by previous studies in elite soccer (Bradley et al., 2009; Dellal et al., 2010; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Di Salvo et al., 2007) that have found significant differences in high intensity running (HIR), number of sprints, headers, tackles and total distance covered between different positional roles. When comparing SSGs with competition, few studies have attempted to report the different demands placed upon the players in SSGs due to rule changes in order to prescribe which specific condition assists most closely the technical and physical demands of match-play. In this context, Gabbett and Mulvey (2008) have compared the time–motion characteristics within SSGs (i.e., 3 vs. 3 and 5 vs. 5), domestic and international matches in women soccer players with special reference to high-intensity activities. These authors reported that both the 3 vs. 3 and 5 vs. 5 SSGs recreated match-play physical activity but presented an insufficient training stimulus to simulate the high-intensity and repeated-sprint demands of international competition. Furthermore, the number of ball contacts per individual possession have been described as one of the most important characteristics of the technical activity of elite soccer players during a match-play with players performing between 1.74 and 2.24 ball touches per possession (Dellal, Chamari, Wong, et al., 2011). In this context, few studies have proposed to vary the rule of the number of ball contacts authorized per possession during SSGs and none have examined the corresponding technical and physical adaptation in comparison to elite match-play. Owen et al. (2011) studied the effects of small vs. large sided games within elite professional soccer and found that by altering the number of players within the same conditioned games a significantly higher technical and physical response is elicited close to match play.

Consequently, the primary aim of this study was to investigate the effect of manipulating the number of ball contacts authorized by individual possession during 4 vs. 4 SSGs, which most closely

replicate the technical, physical and physiological demands of match-play. The second aim was to examine the impact of playing positions within SSGs as the different activities achieved in comparison to match-play situations. It was hypothesized that (1) one or two ball touches authorized per possession within SSGs may constitute a better choice compared to a free play rule to reflect player's activity during match-play; (2) and the difference in player activities according to playing positions found during a friendly match-play would be similar to those found during 4 vs. 4 SSGs.

2. Methods

2.1. Subjects

Forty outfield international soccer players took part in the study (age 25.3 ± 2.4 years, height 182.4 ± 2.3 cm, body mass 77.3 ± 4.1 kg, maximal HR 198.5 ± 4.9 beats min^{-1}, and percent of body fat 11.2 ± 1.4%). The players were classified according to their playing positional role: central defenders (CD, $n = 8$), full-backs (FB, $n = 8$), central defensive midfielders (CDM, $n = 12$), wide midfielders (WM, $n = 7$) and forwards (FW, $n = 5$). All the players played in their customary position during the two measured friendly matches. Goalkeepers were excluded from the study as they did not participate in the same physical training program as the remainder of the squad. All the players gave written informed consent after a detailed explanation about the aims and risks involved in the investigation. The study was conducted according to the Declaration of Helsinki and the protocol was fully approved from the internal review board of the sampled professional football team before the commencement of the assessments.

2.2. Experimental approach to the problem

The physical and technical activities of soccer players during various SSGs are well known (Owen et al., 2004). However, to our knowledge, research is limited regarding (1) the manipulation of the number of ball contacts per individual possession, and (2) investigations into different playing positions eliciting different responses within small-sided training games. Due to the literature lacking in this area, physiological responses, technical load, and physical activities were analyzed both during three different 4 vs. 4 SGGs and during two 11-a-side friendly matches (90 min, extra-time was excluded from the analysis). During the different SSGs, the number of ball touches authorized per individual possession was previously fixed (1 ball touch authorized = 1T, 2 ball touches authorized = 2T and Free Play = FP). All SSGs sessions and the two matches were tested in the mid-season and were separated by at least two days. The session were performed at the same time of the day in order to limit the effects of the circadian variations on the measured variables, particularly on heart rate (HR) measurements (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005; Reilly & Brooks, 1986). The SSGs and the two matches were played on the same natural grass soccer field in similarly ambient condition (25–27 °C, 1013 mm Hg atmospheric pressure and 58% relative humidity). The time–motion analysis system used was the GPS system for SSGs and the semi-automatic multiple camera system for the two friendly matches.

2.3. Small-sided games (SSGs) and 11-a-side match play (90 min)

The 4 vs. 4 SSGs were implemented in random order over the duration of the study (4 weeks). The different teams of the SSGs were balanced according to the different playing positions. The pitch size (30 × 20 m) and the duration (4 × 4 min separated by 3 min of passive recovery) of each SSG were strictly controlled and have been implemented by other researchers (Dellal, Chamari, Owen, et al., 2011; Dellal et al., 2008; Hill-Haas et al., 2010; Rampinini et al., 2007). The SSGs were performed with four supporting players situated out of the playing area, with the instruction to maintain collective possession of the ball for the longest time as possible. Several balls were disposed all around these areas for immediate availability to minimize any disruption of play, and thus, the total duration of SSGs was the effective time of exercise. All the SSGs were preceded by a 20-min standardized

warm-up. Players were allowed to consume available drinks ad libitum during the recovery periods. The coaches verbally encouraged the players throughout the different SSGs to maintain a high work-rate.

Players also participated in two 11-a-side friendly matches played with no substitution on the same the surface area (100 × 60 m). The extra-time in each halve was excluded from the analysis and thus only the activities during the 90 min were analyzed.

2.4. Physiological responses

Maximal heart rate (HR_{max}) was determined by the completion of the Yo–Yo Intermittent Recovery Test Level 2 (Krustrup et al., 2003) in which the highest values of HR reached during the test corresponded to the HR_{max}. The resting HR was recorded with the players laid on a bed for 10 min at 10:30 AM. The resting HR value corresponded to the minimal HR observed during the 10-min period. Heart rate (HR) was continuously monitored throughout the SSGs and the two matches by HR monitors (Polar Team Sport System, Polar-Electro OY, Kempele, Finland) recorded at 5-s intervals. Individual mean HR during match-play and SSGs were determined to indicate the overall intensity. HR data were therefore expressed both as percentage of HR_{max} (%HR_{max}) and reserve HR (%HR reserve) according to the formula previously used by Dellal et al. (2008) and as suggested by Dellal et al. (2012).

Blood lactate samples [La] were collected at the 3rd min respectively post-exercise (SSGs and friendly matches) by a portable analyzer (Lactate Pro, Arkray, Japan), which has been previously validated (Pyne, Boston, Martin, & Logan, 2000).

The 10-point rating of perceived exertion (RPE) proposed by Foster et al. (2001) was employed to determine how hard players found the session, internal intensity and exercise load of the session (Coutts, Rampinini, Marcora, Castagna, & Impellizzeri, 2009; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004) and had been used during the two weeks prior to the investigation to ensure subjects' familiarization. The exercise session-RPE of each player was recorded immediately at the end of each SSG and friendly match using a standardized questionnaire, with no information being provided to the players with respect to any of the previous measurements.

2.5. Time–motion characteristics

The physical performance parameters measured were the total distance, sprint distance and high-intensity running (HIR) distance covered. The systems of time–motion analysis used in SSG and match-play were the GPS and multiple-camera match analysis system, respectively. The activities performed at varying speeds were recorded following the same methodology used in previous studies (Bradley et al., 2009; Dellal, Chamari, Wong, et al., 2011; Hill-Haas et al., 2010). Distances covered per minute were also computed in each situation for further analysis. Randers et al. (2010) showed no statistical differences between the GPS (at 5 Hz) and semi-automatic multiple camera systems in walking, in low or moderate intensity, in sprinting, in total distance covered and for detecting fatigue, whereas a small difference was notified for high-intensity running. In order to improve the comparisons between values from these two technologies, part of the data was analyzed according to the duration of the match-play and SSGs, and in this case, according to the minute of play by exercise.

2.5.1. Time–motion characteristics within match-play

A multiple-camera match analysis system (Amisco Pro®, Sport-Universal, Nice, France) was used in order to examine the time–motion characteristics of each player during the two friendly matches on a 100 × 60 m pitch. Eight stable cameras were positioned and subsequently calibrated and synchronized. Signals and angles obtained by the encoders were sequentially converted into digital data and recorded on 6 computers for post-game analysis. The movements of every player over the course of the match were tracked using a sampling rate of 25 Hz. Experienced operators in video match-analysis simultaneously coded each player action involving the ball. Physical performance from the raw data file was determined automatically by computerized analysis of the player movements and activities using match-analysis software (AMISCO Viewer®, Sport-Universal Process, Nice, France). The workings, accuracy and reliability of the AMISCO Pro® system in measuring player movements and

coding game events in professional soccer competition have been described in more detail elsewhere (Di Salvo et al., 2007; Zubilaga, 2006).

2.5.2. Time–motion characteristics within SSGs

The physical activities were analyzed using a portable global positioning satellite (GPS) system (GPSports SPI Elite System, Canberra, Australia) in which the distance traveled was recorded at 5 Hz. This technology has been previously determined as reliable and validated for monitoring the players' high-intensity and sprinting activities in soccer (Barbero-Álvarez, Coutts, Granda, Barbero-Álvarez, & Castagna, 2010; Coutts & Duffield, 2010; Edgecomb & Norton, 2006; Jennings, Cormarck, Coutts, Boyd, & Aughey, 2010). This system of GPS presents a coefficient of variation of 3.6% for total distance, 11.2% for high intensity running and 5.8% for sprinting (Coutts & Duffield, 2010). Moreover, Barbero-Álvarez et al. (2010) confirmed the use of GPS as an alternative to assess repeated sprint performance (RSA) with especially strong correlations between GPS and RSA performance measured with time lights for the 15 m (r^2 = .87) and 30 m (r^2 = .94) splits, knowing that sprint distance is rarely over 30 m in soccer games (e.g., Bradley et al., 2009). The small difference of HIR values between the GPS and semi-automatic video technology could be due to the stress upon players by the wear of the GPS material system. Indeed, the GPSs were placed on the upper back inside a neoprene pouch attached to a harness around the player's shoulder, inside another pouch sewn into a sleeveless undershirt.

2.6. Technical activity

Four fixed digital video cameras were positioned all around the SSG area to film the players' technical actions, whereas three cameras were used during match-play. Duels (1 player with the ball possession vs. 1 player without it; or 2 players who like to gain the ball possession), percentage of successful passes, total number of lost balls (both in duels or other technical actions as dribbling and passing) and total number of ball possessions were evaluated by a hand notational system similar to that previously employed by Owen et al. (2004). The video recordings were played-back several times to ensure the validity of the data. Special attention was applied in order to ensure the reliability of technical observations during SSGs. Therefore, reliability of this procedure was assessed by the re-analysis of one designated SSG by the investigator. The number of exact agreements observed between each of the two analyses provided the level of agreement for the evaluation of technical activities within SSGs according to Kelly and Drust (2009) and Drust, Atkinson, and Reilly (2007). To enable this statistic calculation, an observation-by-observation breakdown of the results was obtained for each data analysis. This method was then supplemented by the calculation of kappa corresponding to the number of agreements observed. The reliability values were 90% (k = .90) for the successful passes, 88% (k = .88) for the total number of ball lost, 85% (k = .85) for duels, and 87% (k = .87) for the total number of ball possessions. The results indicated altogether an "almost perfect" strength of agreement according to Landis and Koch (1977).

3. Statistical analysis

Data are expressed as means ± standard deviations (*SD*). Before using a parametric statistical test procedure, the normality of the data was verified by the Shapiro-Wilks test. A two-way analysis of variance (ANOVA) with repeated measures was used to test for the differences in performance measurements between each number of ball touches conditions during each SSG (1T, 2T and FP) and the two friendly matches. Concerning the *post hoc* analysis, follow-up univariate analyses using Bonferroni-corrected pairwise comparisons were used where appropriate. All statistical analysis was performed using SPSS Statistical Analysis Software for Windows® (SPSS, version 17.0, Chicago, USA). The level of significance was set at $p < .05$. Effect sizes for these differences were also determined. Effect sizes values of .20–.49, .50–.79, and $\geqslant$.8 were considered to represent small, medium, and large differences, respectively (Cohen, 1988).

4. Results

4.1. Time–motion characteristics

The players covered greater total distances both in sprinting and in HIR ($p < .001$ for all playing positions, .39–.48 effect sizes) during the three 4 vs. 4 SSGs, especially within the 1T and 2T rules in comparison to match-play (Table 1). These differences were even greater when the analysis was expressed in relation to percentage of the total distance covered. Moreover, the percentages of total distance covered in sprinting ranged from 14.2% to 16.8% and in HIR from 17.2% to 21.9% during SSGs. On the other hand, these values ranged from 2.1% (sprinting) to 3.3% (HIR) during match-play ($p < .001$, .26–.42 effect sizes, Figs. 1 and 2). In the same context, greater total distances covered per minute of play were observed during SSGs in comparison to match-play ($p < .001$ for all playing positions, .76–.83 effect sizes Fig. 3) while SSGs played in 1T and 2T rules presented significant differences with 4 vs. 4 FP rules for all playing positions (Fig. 3).

4.2. Physiological responses

Although more high-intensity running activities (sprinting and HIR) were performed during the SSGs, the [La] recorded in all the three SSGs were significantly lower ($p < .001$, .23–.32 effect sizes) in comparison to the friendly match-play, irrespective of playing position (Table 2).

The RPE results presented similar values between match-play and SSGs played in 1T and 2T rules irrespective of playing position (except for FW). However, FB, CDM, WM and FW presented significantly lower values of RPE when the SSG was played in FP rule as compared to match-play (Table 1).

The HR responses showed varied results according to the playing positions and the game rules (Table 1). Indeed, the HR responses of CD and FW both expressed as $\%HR_{max}$ and %HR reserve were greater during all the SSGs in comparison to those found during the friendly match. In contrast, FB and WM presented only different HR responses when SSG was played with the 1T rule, whereas CDM showed only differences when SSGs were played in 2T and FP rules (Table 1).

4.3. Technical demands

Significant differences were found within the technical demands between all the SSGs tested and match-play (Table 1). Specifically, a greater number of duels and lost balls, and a lower percentage of successful passes and total number of ball possessions were found during the different SSGs for all playing positions in comparison to match-play values (.38–.63 effect sizes). However, compared to the other playing positions, the FW presented similar values during the SSGs and match-play regarding the percentage of successful passes (in the 2T rule), the total number of balls lost (1T rule) and the total number of possessions (1T rule).

5. Discussion

The demands of elite soccer match-play and small-sided games (SSGs) have been frequently described in literature. Therefore, the aim of the present study was to compare the physical performance, physiological responses and technical demands of soccer players within a real match-play situation and SSGs in relation to the positional roles of the players. The findings of the investigation suggest that 4 vs. 4 SSGs with specific conditions imposed (1 or 2 ball touch rules), induce a high proportion of high-intensity running, significant loading of the aerobic system (HR response) as well as complicated technical challenges. In addition, SSGs and match-play scenarios presented the same outcome when comparing the physical and technical activities according to positional roles. It may be suggested that information from this investigation could be valuable for coaches, sports scientists and other individuals involved with the physical or technical development of players when developing or applying SSGs for training drills. Moreover, coaches should pay special attention to positional roles when including SSGs within their training program.

Table 1
Physical and technical variables associated with 4 vs. 4 SSGs and two 11-a-side friendly match-play in elite male soccer players (means ± *SD*. *n* = 40).

			Total distance covered (m)****		Total distance covered in sprinting (m)****		Total distance covered in HIR (m)****		Number of duels		% of successful passes		Total number of balls lost		Total number of ball possession	
Match-play	CD (*n* = 8)		10,671	±301	232	±52.1	315	±61.2	16.2	±2.6	79.0	±2.0	8.5	±2.2	45.6	±7.2
	FB (*n* = 8)		11,217	±405	309	±70.0	374	±55.0	14.1	±3.0	81.0	±3.2	8.0	±2.7	57.3	±10.6
	CDM (*n* = 12)		11,885	±546	317	±63.1	371	±64.2	17.3	±3.9	81.0	±2.1	10.5	±2.1	73.4	±5.9
	WM (*n* = 7)		11,301	±623	303	±51.7	357	±60.0	13.2	±3.0	78.0	±1.7	8.1	±1.9	62.2	±8.2
	FW (*n* = 5)		10,790	±746	315	±69.3	351	±55.3	19.4	±4.2	75.0	±2.4	12.7	±2.4	45.7	±8.2
	Total (*n* = 40)		11,173	±524	295	±61.2	353	±59.1	16.0	±3.3	78.8	±2.3	9.6	±2.3	56.8	±8.0
4 vs. 4 SSGs	CD (*n* = 8)	*1T*	2950	±163	463	±59.3	593	±57.1	19.9***	±3.4	45.2***	±4.8	15.8***	±4.0	38.5***	±4.0
		2T	2691	±187	390	±61.6	530	±62.1	19.0***	±2.9	61.6***	±4.2	15.3***	±3.7	32.4***	±3.3
		FP	2467	±192	350	±55.3	424	±67.2	27.2***	±3.0	70.9***	±6.6	14.3***	±4.5	30.1***	±34
	FB (*n* = 8)	*1T*	3050	±237	488	±60.9	622	±54.2	19.1***	±3.5	49.1***	±5.0	16.2***	±4.1	42.3***	±4.4
		2T	2867	±192	453	±61.3	565	±63.3	18.2***	±3.0	68.2***	±4.7	14.7***	±3.6	33.8***	±3.5
		FP	2691	±210	385	±54.1	479	±69.8	29.8***	±3.1	73.0***	±7.0	13.9***	±4.6	30.5***	±3.2
	CDM (*n* = 12)	*1T*	3144	±299	519	±61.1	673	±56.1	17.0*	±3.6	52.1***	±4.1	13.9***	±4.0	42.8***	±4.3
		2T	2902	±252	467	±62.8	580	±67.2	12.8***	±3.4	72.5***	±4.0	13.1***	±4.3	36.1***	±3.6
		FP	2904	±275	427	±57.3	531	±70.5	22.2***	±3.5	73.2***	±7.0	13.1***	±4.8	32.6***	±3.6
	WM (*n* = 7)	*1T*	3112	±287	513	±60.7	660	±56.3	18.9***	±3.7	49.3***	±6.4	15.1***	±4.9	42.6***	±4.5
		2T	2851	±241	456	±62.9	584	±68.5	18.3***	±3.6	69.5***	±6.0	13.8***	±4.8	35.3***	±3.9
		FP	2802	±251	403	±55.2	521	±73.8	27.0***	±4.1	72.9**	±7.6	13.4***	±4.9	31.9***	±3.7
	FW (*n* = 5)	*1T*	3032	±262	509	±60.5	664	±57.3	15.1***	±3.9	53.3***	±6.7	13.0	±5.0	41.8	±4.8
		2T	2760	±229	444	±62.9	569	±70.9	14.7***	±3.6	73.2	±6.1	11.6**	±5.1	35.9***	±4.2
		FP	2456	±256	366	±61.1	481	±74.7	19.3*	±4.3	77.5*	±7.8	11.3**	±5.2	32.4***	±4.1
	Total (*n* = 40)	*1T*	3057	±250	493	±60.5	639	±56.2	18.0	±3.6	49.8	±5.4	14.8	±4.4	41.6	±4.4
		2T	2815	±220	438	±62.3	563	±66.4	16.6	±3.3	69.0	±5.0	13.7	±4.3	34.7	±3.7
		FP	2664	±237	382	±56.6	483	±71.2	25.1	±3.6	73.5	±7.2	13.2	±4.8	31.5	±3.6

CD: Central defenders; FB: Full-backs; CDM: Central defensive midfielders; WM: Wide midfielders; FW: Forwards. 1T: One ball touch authorized per individual possession; 2T: Two ball touches authorized per individual possession; FP: Free-play. HIR: High-intensity running.

* Significant differences between values during match-play and the 4 vs. 4 SSGs for a specific playing position $p < .05$.

** Significant differences between values during match-play and the 4 vs. 4 SSGs for a specific playing position $p < .01$.

*** Significant differences between values during match-play and the 4 vs. 4 SSGs for a specific playing position $p < .001$.

**** Significant differences for each playing position during match-play and the 4 vs. 4 SSGs $p < .001$.

Table 2
HR responses blood lactate concentrations and rating of perceived exertion (RPE) values associated with three 4 vs. 4 SSGs and two 11-a-side friendly matches in elite male soccer players (means ± *SD*, *n* = 40).

			Blood lactate (mmol l^{-1})****		RPE (CR-10)		%HR_{max}		%HR reserve	
Match-play	CD (*n* = 8)		4.2	±0.3	7.5	±0.4	81.7	±2.3	75.9	±1.9
	FB (*n* = 8)		4.4	±0.3	8.0	±0.2	83.2	±2.2	78.2	±1.8
	CDM (*n* = 12)		5.4	±0.6	8.2	±0.4	86.3	±2.4	82.8	±1.8
	WM (*n* = 7)		4.9	±0.5	8.1	±0.6	83.7	±3.2	78.6	±2.1
	FW (*n* = 5)		5.0	±0.2	8.0	±0.7	81.2	±2.9	75.3	±2.0
	Total (*n* = 40)		4.8	±0.4	7.4	±0.5	83.2	±2.6	78.2	±1.9
4 vs. 4 SSGs	CD (*n* = 8)	*1T*	3.3	±0.4	8.3	±0.6	88.9**	±2.9	85.2***	±3.7
		2T	3.2	±0.2	8.2	±0.6	87.1**	±3.3	83.0***	±4.4
		FP	3.1	±0.2	7.7	±0.5	85.9*	±2.5	81.3***	±3.3
	FB (*n* = 8)	*1T*	3.0	±0.3	7.9	±0.5	87.4*	±2.6	83.5***	±3.4
		2T	2.9	±0.1	8.0	±0.7	85.9	±3.0	81.5	±4.1
		FP	2.8	±0.2	7.5*	±0.5	84.9	±2.9	80.2	±3.7
	CDM (*n* = 12)	*1T*	3.0	±0.3	8.0	±0.7	86.3	±2.4	82.2	±3.2
		2T	2.9	±0.1	7.9	±0.6	83.9**	±2.9	79.1*	±4.0
		FP	2.7	±0.1	7.2***	±0.5	82.8**	±3.0	77.6**	±3.8
	WM (*n* = 7)	*1T*	2.9	±0.2	7.9	±0.9	88.8*	±2.3	85.1***	±3.1
		2T	2.8	±0.1	7.8	±1.0	86.6	±3.1	82.0	±4.2
		FP	2.7	±0.1	7.1***	±0.7	86.5	±2.5	82.0	±3.3
	FW (*n* = 5)	*1T*	2.8	±0.3	7.9	±0.8	88.9***	±2.3	84.8***	±3.1
		2T	2.7	±0.2	7.6**	±1.1	86.4***	±3.3	81.3***	±4.4
		FP	2.7	±0.2	7.0***	±0.8	85.6**	±2.6	80.2***	±3.4
	Total (*n* = 40)	*1T*	3.0	±0.3	8.0	±0.7	87.6	±2.5	83.6	±3.3
		2T	2.9	±0.1	7.9	±0.8	85.6	±3.0	80.8	±4.1
		FP	2.8	±0.2	7.3	±0.6	84.7	±2.7	79.7	±3.5

CD: Central defenders; FB: Full-backs; CDM: Central defensive midfielders; WM: Wide midfielders; FW: Forwards 1T: One ball touch authorized per individual possession; 2T: Two ball touches authorized per individual possession; FP: Free-play HIR: High-intensity running.

* Significant differences between values during the match-play and the three 4 vs. 4 SSGs, for a specific playing position $p < .05$.

** Significant differences between values during the match-play and the three 4 vs. 4 SSGs, for a specific playing position $p < .01$.

*** Significant differences between values during the match-play and the three 4 vs. 4 SSGs, for a specific playing position $p < .001$.

**** Significant differences for each playing position during the match-play and the three 4 vs. 4 SSGs $p < .001$.

SSGs have been previously described as a soccer conditioning exercise that allows an improvement of the aerobic capacity of players (Dellal et al., 2008; Kelly & Drust, 2009). HR monitoring has been traditionally used during these drills in order to examine the physiological requirements of the SSGs. Dellal et al. (2008) found no differences in the %HR reserve during a 4 vs. 4 and a 10 vs. 10 training drill with goalkeepers. In contrast, the results of the present study showed that all the positional roles studied (CD, FB, CDM, WM and FW) presented significantly higher HR response during 4 vs. 4 SSGs than the average values for the match-play. This finding is in accordance to those of Owen et al. (2011) who showed that players presented higher HR responses during 3 vs. 3 than larger sided-games (9 vs. 9). These different results could be explained by the fact that SSGs induce a greater technical, physical and tactical implication of all players both in offensive and defensive phases. Moreover, the period of recovery could be shorter during SSGs as compared to friendly match-play, whereas the number of activities per minute of play is greater within SSGs ($p < .001$). In the same context, Allen, Butterfly, Welsh, and Wood (1998) showed greater cardiovascular values during a 5 vs. 5 training situation in comparison with match-play. These differences in HR response between SSGs and match-play presented by Allen et al. (1998) could be due to the variation of the total duration of the SSGs (2×4 min vs. 4×4 min), which probably was insufficient time to allow cardiac adaptations. However, using HR to monitor exercise responses has not been considered as the best indicator to examine the physical physiological requirements during SSGs. The RPE has been used as an alternative measure of the soccer-training load (Rampinini et al., 2007) that allows for the analysis of the global internal

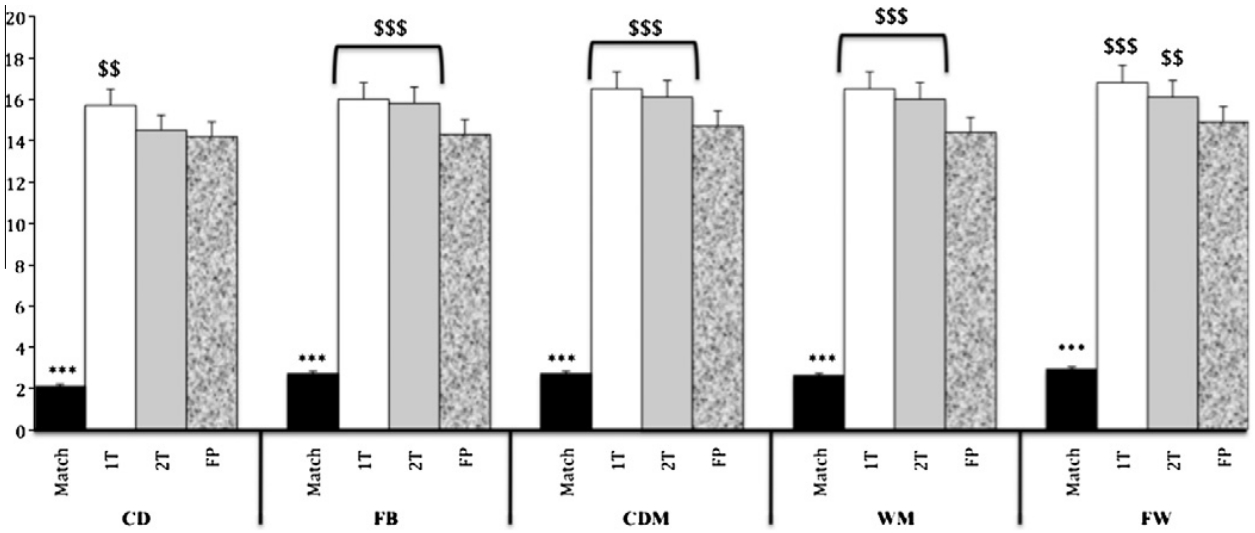

Fig. 1. Percentage of total distance covered in sprinting during the three 4 vs. 4 SSGs and two 11-a-side friendly matches (means ± *SD*, *n* = 40).***significantly lower total distance covered in sprinting during match-play compared to the three 4 vs. 4 SSGs.;***$p < .001$. $^{\$\$\$}$significantly higher percentage of the total distance covered in sprinting compared to the three 4 vs. 4 SSGs in FP rules.; $^{\$\$}p < .01$; $^{\$\$\$}p < .001$. CD: Central defenders; FB: Full-backs; CDM: Central defensive midfielders; WM: Wide midfielders; FW: Forwards. 1T: One ball touch authorized per individual possession; 2T: Two ball touches authorized per individual possession; FP: Free-play.

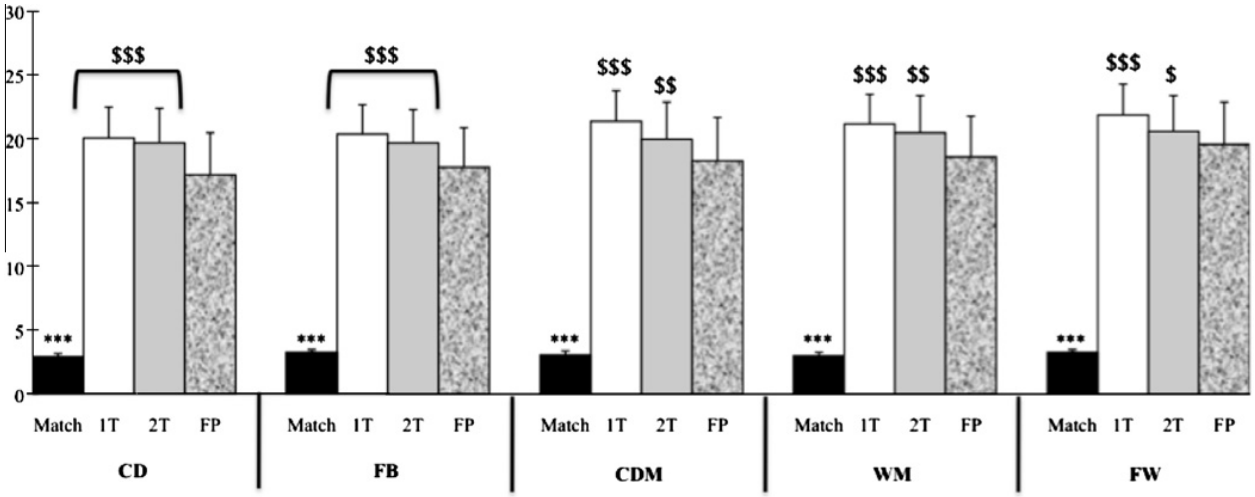

Fig. 2. Percentage of the total distance covered in HIR during the 4 vs. 4 SSGs and two 11-a-sided friendly matches in elite soccer (means ± *SD*, *n* = 40). HIR : High-intensity running. ***significantly lower total distance covered in HIR during match-play compared to all the three 4 vs. 4 SSGs. ***$p < .001$. $^{\$\$\$}$significantly higher percentage of the total distance covered in HIR compared to the Free Play SSG. $^{\$\$}p < .01$; $^{\$\$\$}p < .001$ CD: Central defenders; FB: Full-backs; CDM: Central defensive midfielders; WM: Wide midfielders; FW: Forwards 1T: One ball touch authorized per individual possession; 2T: Two ball touches authorized per individual possession; FP: Free-play.

load (Alexiou & Coutts, 2008; Coutts et al., 2009; Jones & Drust, 2007). The results of the present study showed that the values of RPE were similar between match-play and 4 vs. 4 SSGs played in 1T or 2T rules whereas FP appeared to be perceived easier than all the previous situations. SSGs played in 4 vs. 4 with FP rule appeared to be perceived less difficult than SSGs played in 1T and 2T rules and match-play. It would be expected from this data that the FP rule could induce a lower intensity within SSGs both concerning the physical and technical activities, which could allow that players better tolerate this type of training instead of SSGs played in 1T or 2T rules. Interestingly, in spite of greater number high-intensity running bouts per minute of play observed during SSGs of the present study ($p < .001$), blood lactate concentration was lower during the SSGs than during match-play. Due to more

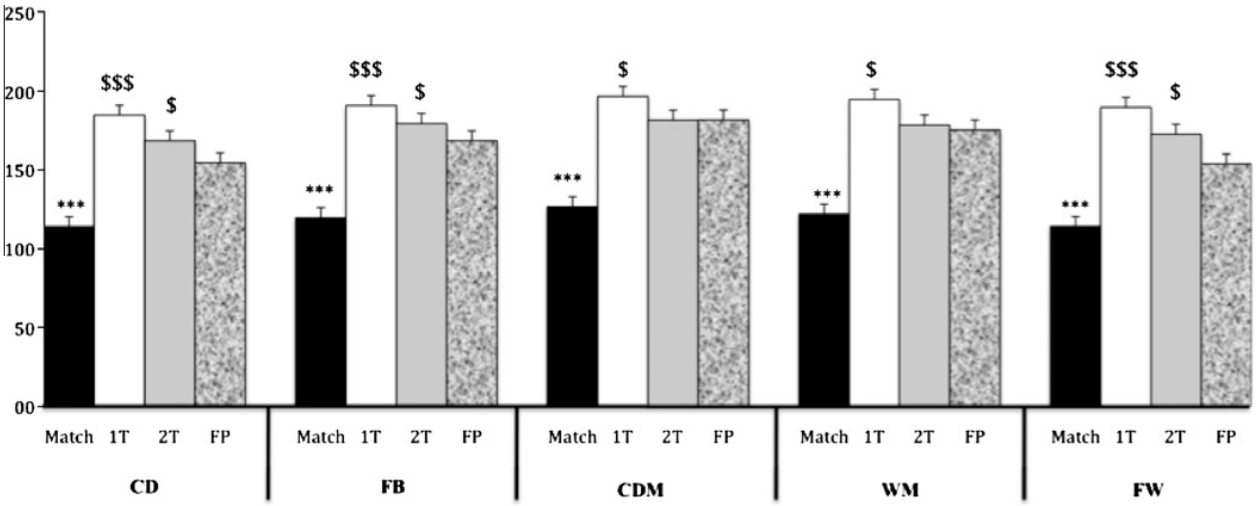

Fig. 3. Total distance covered per minute of play across the three 4 vs. 4 SSGs and two 11-a-side friendly matches in elite soccer players (means ± *SD*, *n* = 40). ***Significantly lower total distance covered during match-play compared to the three 4 vs. 4 SSGs. ***$p < .001$ $^{\$\$\$}$significantly higher value of the total distance covered compared to the Free Play 4 vs. 4 SSG. $^{\$}p < .05$; $^{\$\$}p < .01$; $^{\$\$\$}p < .001$ CD: Central defenders; FB: Full-backs; CDM: Central defensive midfielders; WM: Wide midfielders; FW: Forwards 1T: One ball touch authorized per individual possession; 2T: Two ball touches authorized per individual possession; FP: Free-play.

high-intensity running being performed during the SSGs, the anaerobic energy turnover would be expected to contribute more to the muscle metabolism in SSGs as compared to match-play. However, the lower blood lactates in the SSGs may well be explained by the fact that the high-intensity running bouts were shorter in duration in the SSGs causing a higher reliance on ATP and CP breakdown rather than anaerobic glycolysis. Furthermore, resynthesis of PCr, reloading of oxygen in myoglobin and heamoglobin, and a partial removal of [La] may have occurred during the 3 min-periods of passive recovery (Christmass, Dawson, & Arthur, 1999; Dupont, Blondel, & Berthoin, 2003). However, a 1 vs. 1 SSG induces higher blood lactate concentration than 2 vs. 2, 3 vs. 3 and 4 vs. 4 SSGs, probably because there is never a recovery period within the SSG inducing a sub-maximal or maximal values of blood lactate concentration (it depends on bouts duration). All these physiological responses provided some interesting elements but it is important to link these physiological results with time–motion characteristics and technical activity.

Traditionally, physical performance in elite soccer has been evaluated through time–motion analysis (e.g., Bradley et al., 2009). The results of the present study revealed that high-intensity activities (sprinting and HIR) were greater during SSGs than in match-play, especially when SSG were played with the 1T and 2T rules. These differences were increased when the sprinting and HIR activities were expressed as a percentage of the total distance with values of ~6 times greater in SGGs as compared to match-play (14.1–21.8% vs. 2.2–2.9%, respectively). These findings are very important as elite male soccer is characterized by the amount of high-intensity activities performed by the players, whereas the number of ball touches per possession should be lowered, to be able to impose a high tempo on the game (Dellal, Chamari, Wong, et al., 2011). In contrast to these findings, previous studies (Allen et al., 1998; Gabbett & Mulvey, 2008) revealed no significant difference when comparing sprint and HIR distance covered between SSGs and match-play for male amateur and female soccer players. However, essentially it does appear that players carry out more HIR and sprinting during SSGs when compared to match-play. This may be due primarily the size of the playing field (30×20 m vs. $\sim 100 \times 60$ m, respectively) rather than any other physical or technical component. Additionally, recent research has clearly shown that match performance indices may vary markedly from game to game (Gregson, Drust, Atkinson, & Salvo, 2010) and that GPS and semi-automatic multiple camera system have presented significant differences with the time–motion results for high-intensity running excluding sprinting (Randers et al., 2010). Therefore, this could constitute a limitation in the comparison between match-play and SSGs training.

The relevance and interest of SSGs in modern soccer training can be attributed to the fact that they offer a multifunctional training benefit by influencing simultaneously players' physical, technical and tactical abilities (Owen et al., 2004, 2011). This method is common within elite level soccer but has higher inter-player variability during the SSGs as compared to a traditional short-duration intermittent exercise (Dellal et al., 2008), circuit training and interval training (Hill-Haas et al., 2010). The physical, technical and tactical demands of SSGs should be fully understood by coaches, and, at the same time, require care when administering them within a training structure as rule changes may influence the intensity of the exercise (Hill-Haas et al., 2010; Owen et al., 2011) and affect at the same time the quality of the training session. Findings from the present study reveal how the technical demands affect players in different positional roles. Results suggest how CDs performed the lowest number of ball touches per possession during a competitive match (Dellal, Chamari, Wong, et al., 2011) and during the actual SSGs presented a lower percentage of successful passes and total number of balls lost than the midfielders (CDM, WM) and the forwards. The CDs are usually the players with the weakest technical abilities in a soccer team and are not used to play in reduced spaces with a greater density of players. Although the CDs are the players who perform the lowest number of ball touches by possession during a match-play (Dellal, Chamari, Wong, et al., 2011). Additionally, the present study showed that the SSGs recreated the technical activity described during match-play only when the games were played beyond the FP rule for all playing positions. The 1T and 2T rules increased the difficulty for the players to perform technical actions as there were greater number of balls lost in comparison to SSG free play and the friendly 11-a-side game. In comparison to previous research (Allen et al., 1998; Owen et al., 2004), this study suggested that the volume of technical activities was greater in 5 vs. 5 than in 11 vs. 11 match-play. More specifically, although the results of the present study reveal that the total number of ball possessions were significantly lower during SSGs than in match-play, the number of balls lost were greater whereas the percentage of successful passes were lower according to all playing positions. It should however be noted that within the SSGs, players are faced with more duels, which are considered as a key factor in elite soccer. Indeed, the numbers of duels found during SSGs were greater than those presented during match-play for all playing positions and for all rule changes, except for the FW who are often exposed to these situations in the course of a match. The FP rule allowed increasing the number of duels but not the difficulty to perform a technical action. Consequently, the most important technical actions described in a modern elite match-play could be recreated and favored during 4 vs. 4 SSGs, especially if they are played under 1T and 2T rules.

6. Conclusions

It should be concluded that the main findings of the present study reveal how 4 vs. 4 small-sided games (SSGs) allowed the players to recreate both the technical and physical activities they are exposed to when in competitive matches. Interestingly, the individual distances covered by sprinting and high intensity running (HIR) were greater during SSGs when compared to match-play. In conjunction to these findings, the percentage of successful passes was lower for all playing positions however, when specific conditioned rules were imposed within the SSGs (1T and 2T), the proportions of high-intensity activities were greatly increased for all playing positions. On the other hand, blood lactate concentrations during SSGs showed lower values than those found at the end of match-play. Changing the number of ball touches per possession has shown to significantly influence the intensity of the training session and cause differing adaptations. In this context, it appears that the technical demands imposed on elite soccer players during SSGs are linked with their playing positions. Specifically, the CDs were not at ease during SSGs probably due to the fact that they did not receive the ball in such small spaces and usually played long passes to the forwards during real match-play. On the contrary, performances and activities of forwards were close to those found in match-play. Consequently, the coach should pay attention to the design of SSGs taking into consideration both the players positional roles and the number of ball touches authorized per individual possession. Within elite level soccer, imposing specific rule changes or conditions (1T or 2T) can alter the outcome of the session and be more specific to competitive technical demands. Administering SSGs as part of a training program at an elite professional soccer level can influence simultaneously more than one fundamental

component of the game in conjunction to each other. However, several limitations regarding the use of SSGs during training should be taken into consideration. SSGs could potentially affect team performance due to playing within smaller pitch areas which subsequently reduces pitch ratio per player and induce short and medium distance passes, which may be less useful for teams with a direct style (long passes) of play.

Competing interests

None declared.

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