



Journal of Human Sport and Exercise

E-ISSN: 1988-5202

jhse@ua.es

Universidad de Alicante

España

CAMPOS VÁZQUEZ, MIGUEL ÁNGEL; CASAMICHANA GÓMEZ, DAVID; SUÁREZ
ARRONES, LUIS; GONZÁLEZ JURADO, JOSÉ ANTONIO; TOSCANO BENDALA,
FRANCISCO JAVIER; LEÓN PRADOS, JUAN ANTONIO
Medium-sided games in soccer: physical and heart rate demands throughout successive
working periods
Journal of Human Sport and Exercise, vol. 12, núm. 1, 2017, pp. 129-141
Universidad de Alicante
Alicante, España

Available in: <http://www.redalyc.org/articulo.oa?id=301051218011>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in redalyc.org


redalyc.org

Scientific Information System

Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal

Non-profit academic project, developed under the open access initiative

Medium-sided games in soccer: physical and heart rate demands throughout successive working periods

MIGUEL ÁNGEL CAMPOS VÁZQUEZ¹ , DAVID CASAMICHANA GÓMEZ², LUIS SUÁREZ ARRONES³, JOSÉ ANTONIO GONZÁLEZ JURADO¹, FRANCISCO JAVIER TOSCANO BENDALA⁴, JUAN ANTONIO LEÓN PRADOS¹

¹ Faculty of Sport, Pablo de Olavide University, Sevilla, Spain

² European University of the Atlantic, Santander, Spain

³ Pablo de Olavide University, Sevilla, Spain

⁴ Catholic University "San Antonio", Murcia, Spain

ABSTRACT

This research compared the physical and heart rate demands of three medium-sided games with the same number of players per team (six) but different playing areas throughout four successive working periods. The two games played in relatively larger areas (large and medium) were performed with regular goals and goalkeepers, so the most reduced game (short) was performed without goals. Nine professional soccer players participated in this study. Meaningful differences were found ($p < 0.05$) on the physical demands in the three proposals, with higher values for the games performed on larger areas: maximum speed: 22.8 ± 2.4 , 19.8 ± 2.3 , and 17.6 ± 1.8 Km/h; and distance covered/min: 120.5 ± 13.4 , 103.4 ± 11.2 , and 93.8 ± 11.6 m/min in large, medium and short game respectively. There were no differences on the heart rate responses among them. When the physical demands were analysed during the four working periods, the differences could only be seen in large game ($p < 0.05$). The first periods in this proposal showed higher values in distance covered/min, maximum speed, and distance/h in the speed zones 7.0-12.9, 13.0-17.9, and 18.0-20.9 Km/h, and lower values in the zones 0-6.9 Km/h, demonstrating, throughout the periods, the tendency to reduce the distance at high speed and to increase the distance at lower speed. These changes in the activity patterns, related to the period of exercising, could depend on the dimensions of the playing field, thus showing



Corresponding author. Faculty of Sport, Pablo de Olavide University, Sevilla, Spain.

E-mail: camposvazquez@hotmail.com

Submitted for publication January 2015

Accepted for publication May 2017

JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

© Faculty of Education. University of Alicante

doi:10.14198/jhse.2017.121.11

a possible effect of fatigue only in those games played in relative higher areas . **Key words:** SMALL-SIDED GAMES, ACTIVITY PATTERNS, HEART RATE RESPONSE, BOUTS, FOOTBALL

Cite this article as:

Campos Vázquez, M.A., Casamichana Gómez, D., Suárez Arrones, L., González Jurado, J.A., Toscano Bendala, F.J., & León Prados, J.A. (2017). Medium-sided games in soccer: physical and heart rate demands throughout successive working periods. *Journal of Human Sport and Exercise*, 12(1), 129-141. doi:10.14198/jhse.2017.121.11

INTRODUCTION

The small-sided games (SSG) are among the most frequently used exercises by soccer coaches (Rampinini et al., 2007), due to their capacity to develop the technical-tactical skills of the players (Dellal et al., 2012) and to improve aerobic fitness (Impellizzeri et al., 2006), along with their capability to perform high-intensity intermittent exercise (Hill-Haas et al., 2009). However, the physical-physiological response of the players in this kind of task is conditioned by manipulating certain variables (Dellal et al., 2012), such as the number of participating players (Castellano et al., 2013; Dellal et al., 2011; Hill-Haas et al., 2009), the size of the playing field (Casamichana and Castellano, 2010; Kelly and Drust, 2009), or the presence or absence of regular goals and goalkeepers (Castellano et al., 2013).

Different researchers have analysed the physiological (Little and Williams, 2006; Rampinini et al., 2007) and physical-physiological demands (Hill-Haas et al., 2009; Owen et al., 2014) on those SSG performed by six players per team, compared to others performed by a different number of participating players. It seems that in this kind of task — classified as medium-sided-games (MSG) (Owen et al., 2014) — heart rate (HR) values can't be reached in the same high proportions as in those SSG performed with fewer players (Hill-Haas et al., 2009; Little and Williams, 2007; Rampinini et al., 2007). Nevertheless, MSG could be used by coaches as the main way to improve those technical-tactical aspects (Owen et al., 2014) such as the development of the game patterns of the team. This aim could be limited in those SSG performed by less than five participating players per team because of its lack of specific positions (Turner and Stewart, 2014). This would suggest MSG as the most interesting line of tasks to develop physical-physiological and tactical-strategic aims simultaneously.

Previous researchers have demonstrated how the manipulation of different variables, such as the size of the playing field (Casamichana and Castellano, 2010) and the modification of other rules (Castellano et al., 2013), could significantly alter HR values and the activity patterns in those tasks involving the same number of participating players. Therefore, these variables should be taken into account by coaches and fitness coaches when designing training sessions through MSG, without neglecting the number of projected working periods, since the physical-physiological demands could vary throughout those SSG training periods (Dellal et al., 2012). The aims of this research were: (i) comparing the physical and HR demands in three MSG with the same number of participating players per team (six), with the MSG designed to assimilate tactical automatisms and involving two variables being modified: the dimensions of the playing field and the presence-absence of goals and goalkeepers; and (ii) examining whether the modification of those two variables had any influence in the physical or HR response throughout the successive working periods within a determined session.

MATERIALS AND METHODS

Participants

Nine professional soccer players (four defenders, three midfielders, and two forwards) took part in the current research (age: 26.2 ± 3.7 years old; height: 179.3 ± 7.1 cm; weight: 75.6 ± 5.8 Kg; % fat mass (Faulkner): 9.93 ± 0.56 ; mean \pm SD). Every player belonged to the same team, played in the 2nd division of the Spanish soccer league (*Liga Adelante*) and had an average of ~ 5.5 years of experience in soccer. All these individuals were previously informed about the aims of this research and the kind of test to be developed. They consented and signed the information according to the indications of the Declaration of Helsinki before this investigation started.

Procedures

The research was performed for one and a half months (April–May). It coincided with the last phase of the competitive season 2012–2013. During this period the team used to carry out five training sessions and an official competition match (Sunday), including one day per week to rest (Tuesday). The day after the resting day (Wednesday) they performed the most intense training session of the week, in which, after the standard warm-up exercises, the players participated in the MSG. All the sessions took place in the morning and on an outdoor natural grass pitch. These sessions normally lasted over 1.5 and 2 hours.

The week before the beginning of this research some anthropometrical assessments were carried out, and the intermittent performance was tested by using the Yo-Yo Intermittent Recovery Test Level-1 (YYIRT-1) (Bangsbo et al., 2008). This latter test was also aimed to determine the maximum HR (HR_{\max}) of the players (Bangsbo et al., 2008). The test took place early in the morning (10:00 am) on a natural grass surface. During this test, every player was monitored with a HR monitor (*Polar Team 2[®]*, *Polar Electro Oy, Finland*) that registered the HR_{\max} reached (186.9 ± 9.8), along with the total distance covered by each player (2782.2 ± 411.8 m). The resting HR (HR_{rest}) was registered (49.7 ± 6.8) before the test was carried out (9:00 am). For that purpose, players were lying in supine position for a 10 minute lapse, considering HR_{rest} the lowest HR registered in that lapse (Dellal et al., 2012).

Medium-Sided Games (MSG)

All the players carried out the three proposals depicted in Table 1. These players were familiar with each proposal because they used to perform them in their training routines. The MSG was designed according to the game criteria and the indications of the team coach. The design of two of the MSG proposals included goals and goalkeepers, and the other MSG trained without goals or goalkeepers. The two MSG that included goalkeepers consisted of a match aimed to score more goals than the opponent, and the MSG without goalkeepers was aimed to maintain the possession of the ball longer than the rival team, keeping the possession when attacking, and pressing to get the possession of the ball when defending. Additionally, when designing the MSG, the dimensions of the playing field were modified (Table 1). Despite having 13 players participating in the three MSG, only nine of them were monitored because of the number of GPS devices (Global Positioning System) available. The teams for each SSG were balanced according to the different positions of the players (Dellal et al., 2012).

Table 1. Characteristics of the medium-sided games

Sided Game	Goalkeepers	Pitch size (length x width)	Playing area	Ratio per player	Length to width ratio
6 vs 6 + 1	NO	20 x 30 m	600 m ²	43 m ²	0.7:1
6 vs 6 + 1	YES	25 x 40 m	1000 m ²	77 m ²	0.62:1
6 vs 6 + 1	YES	50 x 40 m	2000 m ²	154 m ²	1.25:1

In each MSG, one of the players played as neutral (all-rounder) in order to smooth the attacking numerical superiority. His activity was not recorded in order to avoid the influence of this variable in the analyses. In the three MSG, all the players were only allowed to touch the ball a couple of times per individual possession. Some balls were delivered around the playing field to replace the lost ones as soon as possible, thereby minimising regular interruptions (Casamichana and Castellano, 2010). The coach encouraged the players verbally to maintain a high playing intensity (Rampinini et al., 2007).

Every MSG proposal was repeated two times (in different weeks) in the same time frame (10:30 am) in order to avoid the effects of the circadian rhythms on the results (Drust et al., 2005). The order the players followed in the six assessment sessions (three different MSG x two sessions) was established randomly in advance. In every session, after the standard warm-up exercises, four bouts of five minutes of the same MSG were carried out (P1, P2, P3, and P4), including two minutes of passive recovery between bouts, where players were allowed to consume available drinks *ad libitum*.

Reduced MSG without goalkeepers (RP)

6 vs 6+ 1 neutral. The tactical premises for the players were the following: when players are attacking they start the action from pre-established areas; the aim is to maintain the possession of the ball with the help of the numerical superiority caused by the neutral player (Figure 1); when defending, the collective pressure must be remarked. This way of playing was intended to hinder the spatial-temporal demands of the game, and it was meant to recreate the actions that take place on the central area of a playing field in a competition match (Fradua et al., 2013). This is, in fact, the MSG proposal that included a smaller area per player (Table 1).

MSG in a shorter space, and a large space with goalkeepers (SG and LG)

6 vs 6+ 1 neutral. The way the players were settled in the playing field was 1-3-2-1: one goalkeeper, three defenders, two midfielders, and one forward (Figure 1). Whenever there was an infraction, the game was resumed with a ball started by the goalkeeper who had suffered that infraction. The aim was to avoid the game being interrupted so the level of intensity could be maintained. The offside rule wasn't applied. The participation of the neutral player was focused on allowing a numerical superiority and developing the attack with short passes and triangulations. The only difference found between both proposals (SG and LG) were the dimensions of the playing field: the length of the MSG in a large space (LG) was twice the size the one with a shorter space (SG, Table 1).

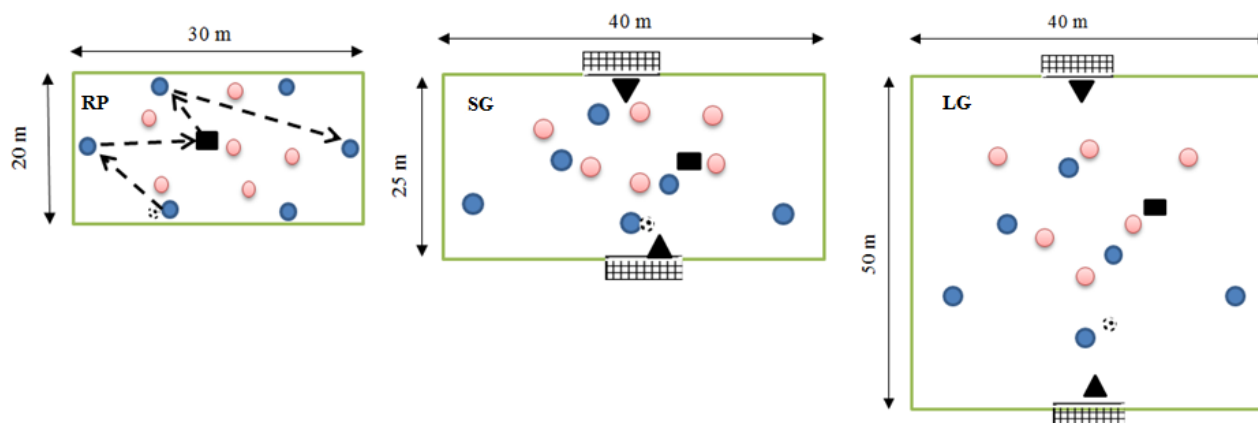


Figure 1. Sketch for illustration of 3 MSGs.

RP: reduced MSG without goalkeepers; SG: MSG in a short space with goalkeepers; LG: MSG in a large space with goalkeepers; ■ : Neutral player ; ▲ : Goalkeeper.

Time-motion analyses

The physical activity profiles in every session were assessed throughout a (GPS), with a sampling rate of 1 Hz (*SPI Elite, GPSports, Canberra, Australia*). All the players wore an adjustable neoprene harness with this device attached to the upper part of their backs. It is proved that these devices are acceptably reliable and accurate when measuring short sprints and repeated sprint performance, if compared to an infra-red timing

system (Barbero-Alvarez et al., 2010). Furthermore, these devices have shown a good level of reliability when measuring the total distance covered by the players in sport teams (coefficient of variation; CV=3-7%) (Coutts and Duffield, 2010) and measuring the pick velocity (CV=1.7%) (Barbero-Alvarez et al., 2010). However, they have proved to be moderately reliable when measuring high intensity running (CV=11-30%) (Coutts and Duffield, 2010). Nevertheless, we can admit that these devices can measure the individual movements patterns in soccer (Randers et al., 2010).

The variables that have been used to assess the activity patterns in the MSG are: a) distance covered per minute (distance/min; DC); b) maximum speed achieved (Vmax); c) distance covered per hour in different speed zones (distance/h): <7.0, 7.0–12.9, 13.0–17.9, 18.0–20.9, and >21.0 km/h. These speed zones are similar to the ones that have been used in previous research (Casamichana et al., 2012); and d) work/rest ratio, defined as the distance covered by the player at a speed >4.0 Km/h (period of activity or work) divided by the distance covered at a speed of 0-3.9 Km/h (period of recovery or rest) (Casamichana et al., 2012).

Analysis

The most relevant descriptive statistical studies were carried out in every variable. The Shapiro Wilk test was applied to check the distribution in every variable. In order to assess the reproducibility of the values obtained in every variable at different days, the T-test was used for repeated measures, or the Wilcoxon test, depending on whether the results presented a normal distribution or not.

Aiming to compare the differences among the recorded measures in every series of each MSG (Intra-MSG) or among every different MSG (Inter-MSG), an ANOVA was carried out for repeated measures by using the Bonferroni's *post-hoc* test to assess the existence of those significant differences found on the independent variables. All the statistical analyses were performed with the statistical software PASW Statistics 18 for Windows. The level of statistical significance was established for $p < 0.05$.

RESULTS

Reproducibility

We found a good level of reproducibility for the different variables that composed the three MSG. The only significant differences among the values were found in both days in distance/h between 0-6.9 Km/h in the task LG ($p = 0.038$) and DC in the task RP ($p = 0.021$).

Comparisons Inter-MSG

The analyses of the activity patterns on the three MSG revealed significant differences among them. The Vmax (22.8 ± 2.4), DC (120.5 ± 13.4), and Work/Rest Ratio (9.5 ± 3.9) in LG was significantly higher than in SG (19.8 ± 2.3 ; 103.4 ± 11.2 , and 6.7 ± 2.6) and RP (17.6 ± 1.8 ; 93.8 ± 11.6 y 5.0 ± 1.5), respectively (Table 2). There were no differences in the HR demands among the three MSG for any of the analysed variables (Table 2).

Table 2. Comparisons Inter-MSG. Mean \pm standard deviation (CV)

	RP	SG	LG
Vmax	17.6 \pm 1.8 (10.3)	19.8 \pm 2.3 ^b (11.4)	22.8 \pm 2.4 ^{a,c} (10.7)
Distance/min	93.8 \pm 11.6 (11.6)	103.4 \pm 11.2 ^b (10.9)	120.5 \pm 13.4 ^{a,c} (11.1)
Work/rest ratio	5.0 \pm 1.5 (29.8)	6.7 \pm 2.6 ^b (39.5)	9.5 \pm 3.9 ^{a,c} (40.5)
% HR _{max}	86.7 \pm 7.7 (8.9)	90.1 \pm 5.1 (5.7)	89.1 \pm 4.6 (5.1)
% HR _{res}	81.7 \pm 11.0 (13.5)	86.5 \pm 7.2 (8.4)	85.1 \pm 6.6 (7.7)
> 85% HR _{max}	13.0 \pm 6.6 (50.9)	16.7 \pm 4.5 (27.2)	15.7 \pm 4.9 (31.1)
70-85% HR _{max}	7.0 \pm 3.6 (51.2)	6.8 \pm 3.0 (44.4)	6.8 \pm 2.9 (42.8)

Post-hoc Bonferroni test: ^aLG>RP; ^bSG>RP; ^cLG>SG. $p < 0.05$.

RP: reduced MSG without goalkeepers; SG: MSG in short space with goalkeepers;

LG: MSG in large space with goalkeepers; HR_{max}: maximal heart rate ; HR_{rest}: resting heart rate;

Vmax: maximum speed (Km/h); > 85% HR_{max}: time (min) at high intensity zone in the session of MSG;

70-85% HR_{max}: time (min) at moderate intensity zone in the session of MSG.

The distance/h obtained in the speed zones 7.0-12.9 (2823.4 \pm 215.0), 13.0-17.9 (1209.8 \pm 307.0); 18.0-20.9 (303.3 \pm 122.4), and >21.0 Km/h (202.2 \pm 86.7) in LG were significantly higher than in SG (2648.1 \pm 298.4, 811.9 \pm 211.9, 120.5 \pm 39.4, and 29.8 \pm 21.0) and RP (2367.7 \pm 453.3, 576.4 \pm 187.2, 32.1 \pm 24.7, and 1.7 \pm 3.4), respectively (Figure 2).

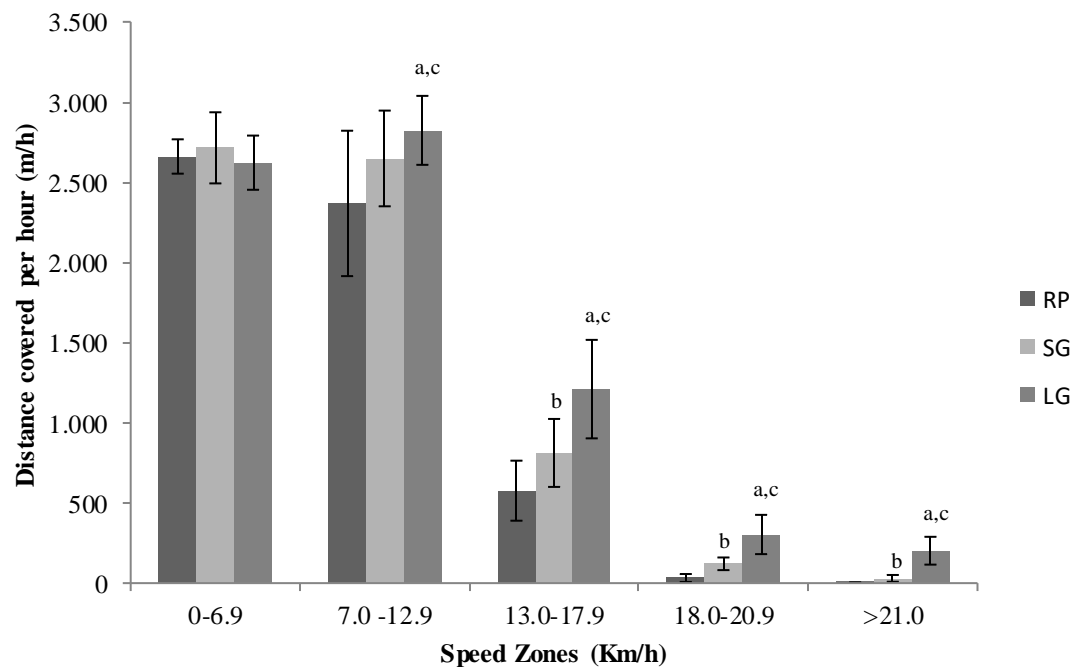


Figure 2. Distance covered per hour in different speed zones in 3 MSGs

RP: reduced MSG without goalkeepers; SG: MSG in short space with goalkeepers. LG: MSG in large space with goalkeepers. Comparisons Inter-MSG. Post-hoc Bonferroni test: ^aLG>RP; ^bSG>RP; ^cLG>SG. $p < 0.05$

Comparisons Intra-MSG

For the proposal of RP, the V_{\max} (17.8 ± 1.4), % HR_{\max} (88.2 ± 6.5), and % HR_{res} (83.8 ± 9.3) in P3 were significantly higher than in P1 (16.9 ± 0.9 , 85.4 ± 6.2 , and 80.2 ± 8.9 , respectively) (Table 3).

Table 3. Comparisons Intra- MSG. Mean \pm standard deviation (CV)

	RP			
	P1	P2	P3	P4
V_{\max}	16.9 ± 0.9^c (5.3)	17.6 ± 1.4 (7.9)	17.8 ± 1.4 (7.9)	18.2 ± 1.1 (6.0)
Distance/min	93.4 ± 9.5 (10.2)	92.9 ± 10.5 (11.3)	96.2 ± 9.9 (10.3)	92.6 ± 10.7 (11.5)
Work/rest ratio	4.9 ± 1.1 (22.4)	5.0 ± 1.2 (24.0)	5.2 ± 1.4 (26.9)	4.8 ± 1.3 (27.1)
% HR_{\max}	85.4 ± 6.2^c (7.3)	86.6 ± 7.1 (8.2)	88.2 ± 6.5 (7.4)	86.7 ± 7.9 (9.1)
% HR_{res}	80.2 ± 8.9^c (11.1)	81.3 ± 10.4 (12.8)	83.8 ± 9.3 (11.1)	81.7 ± 11.5 (14.1)
	SG			
	P1	P2	P3	P4
V_{\max}	19.2 ± 1.4 (7.3)	19.8 ± 1.4 (7.1)	19.7 ± 0.8 (4.1)	20.5 ± 1.9 (9.3)
Distance/min	108.9 ± 8.8 (8.1)	100.9 ± 7.4 (7.3)	99.9 ± 9.4 (9.4)	103.8 ± 11.1 (10.7)
Work/rest ratio	7.4 ± 2.0 (27.0)	6.4 ± 2.2 (34.4)	6.2 ± 2.2 (35.5)	6.7 ± 2.4 (35.8)
% HR_{\max}	89.4 ± 4.4 (4.9)	89.4 ± 4.1 (4.6)	90.6 ± 4.8 (5.3)	90.3 ± 5.3 (5.9)
% HR_{res}	85.5 ± 6.4 (7.5)	85.6 ± 6.1 (7.1)	87.2 ± 6.8 (7.8)	87.1 ± 7.4 (8.5)
	LG			
	P1	P2	P3	P4
V_{\max}	24.4 ± 1.5^a (6.1)	22.9 ± 1.9 (8.3)	22.3 ± 1.6 (7.2)	21.8 ± 1.8 (8.3)
Distance/min	$129.1 \pm 7.1^{a,b}$ (5.5)	122.4 ± 11.1 (9.6)	116.4 ± 12.4 (10.6)	114.2 ± 12.4 (10.8)
Work/rest ratio	10.8 ± 3.0 (27.8)	10.0 ± 2.1 (21.0)	8.1 ± 2.2 (27.1)	9.2 ± 4.3 (46.7)
% HR_{\max}	89.2 ± 3.0 (3.4)	90.4 ± 3.1 (3.4)	88.1 ± 4.7 (5.3)	88.7 ± 4.0 (4.5)
% HR_{res}	85.4 ± 4.4 (5.1)	86.9 ± 4.6 (5.3)	83.8 ± 6.8 (8.1)	84.4 ± 5.7 (6.7)

Post-hoc Bonferroni test: ^aP1>P3; ^bP1>P4; ^cP1<P3. $p < 0.05$. RP: reduced MSG without goalkeepers ; SG: MSG in a short space with goalkeepers; LG: MSG in a large space with goalkeepers; P1-2-3-4 (Period 1-2-3-4); V_{\max} : maximum speed (Km/h); HR_{\max} : maximal heart rate ; HR_{rest} : resting heart rate

In Figure 3 we can observe the distance covered at every speed zone for every bout analysed. We can observe signifying differences in SG, where the distance/h in the zone 7.0-12.9 Km/h in P1 (2888.4 ± 506.9) was significantly higher regarding P3 (2381.2 ± 384.6).

Additionally, for the proposal of LG, the V_{\max} in P1 (24.4 ± 1.5) was significantly higher than P3 (21.8 ± 1.8). Equally, the DC in P1 (129.1 ± 7.1) was significantly higher than in P3 (116.4 ± 12.4) and P4 (114.2 ± 12.4) (Table 3). The distance/h 7-12.9 Km/h and the distance/h 13-17.9 Km/h in P1 (3218.6 ± 363.1 and 1457.0 ± 220.2) were significantly higher than in P4 (2656.2 ± 381.3 and 989.7 ± 423.1). The distance/h 18-20.9 Km/h in P1 (374.3 ± 163.7) was significantly higher than in P3 (229.3 ± 129.6). The distance/h <7.0 Km/h was significantly higher in P3 (2692.9 ± 200.1) and P4 (2773.7 ± 188.4) than in P1 (2411.3 ± 140.1) (Figure 3).

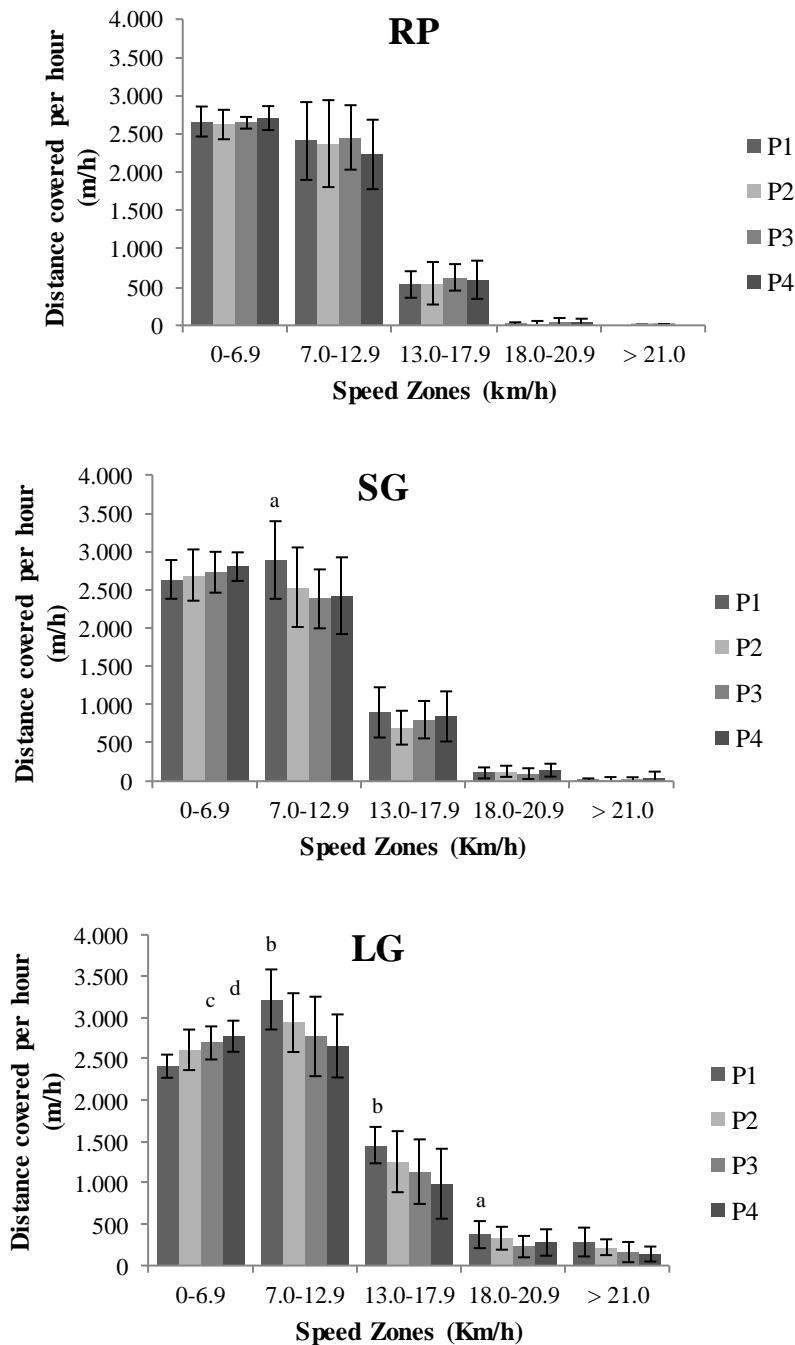


Figure 3. Distance covered per hour in different speed zones in 3 MSGs
 RP: reduced MSG without goalkeepers; SG: MSG in short space with goalkeepers. LG: MSG in large space with goalkeepers. Comparisons Intra-MSG. Post-hoc Bonferroni test: ^aP1>P3; ^bP1>P4; ^cP3>P1; ^dP4>P1; $p < 0.05$

DISCUSSION

The purposes of this research were focused on comparing the physical and HR demands in three MSG with the same number of players participating in each team, but with different rules and playing areas. In addition, the influence of the modification of such variables in the physical and HR responses throughout the successive working periods within the same session was analysed. The results obtained in the research showed differences in the activity patterns in the three proposals; however, the HR responses were similar. Only the playing situation LG presented a decrease in the locomotive activity all along the bouts: it showed a possible “fatigue” effect derived from such a task. These results could demonstrate how the decrease in the locomotive activity during the successive working periods could depend on the dimensions of the playing field, which would only be noticeable in large playing areas.

Previous investigations had already studied the effect of manipulating the playing field dimensions in the HR response in SSG (Casamichana and Castellano, 2010; Kelly and Drust, 2009; Rampinini *et al.*, 2007), and they showed unlike results. Although Kelly and Drust (2009) didn't find differences in professional soccer players (4 vs 4 plus goalkeeper in three different areas: large, medium, and reduced), other investigations carried out with amateur players and similar protocols (Casamichana and Castellano, 2010; Rampinini *et al.*, 2007) concluded that varying the dimensions of the playing field caused different physiological responses, with higher HR for those SSG performed in larger spaces. In our research we didn't find significant differences in the HR response among the three proposals (Table 2), though we did find a higher inter-subject variability (CV) in %HR_{max} and %HR_{res} in RP (8.9 y 13.5) regarding SG (5.7 y 8.4) and LG (5.1 y 7.7). This high inter-subject variability in the response of the HR in RP could advise against its use as a means to improve the aerobic endurance (VO_{2max}), because some players wouldn't be able to reach the 90–95% HR_{max} intensity required (Helgerud *et al.*, 2001). Unlike the data obtained in our investigation, Casamichana *et al.* (2011) found less variability in the HR response in those situations performed without goalkeepers (4 vs 4) when they were compared to those situations that included regular or small goals performed in identical playing areas (100 m² per player). In this sense, the assignment of specific functions can have great relevance. In the research carried out by Casamichana *et al.* (2011), all the players shared the same role, regardless of their assignments, functions, or special preferential locations. However, in our study, considering that players in RP had to go back to their pre-established areas on the attacking phases, the physiological variability imposed on the players could increase. What's more, the relative playing area — smaller than the ones in rest of proposals — could have conditioned the highest physiological variability found in the only task performed without goals in our research.

Casamichana *et al.* (2010) studied the physical responses derived from manipulating the playing field dimensions in SSG with the same number of participating players. This investigation analysed three SSG proposals (5 vs 5 with goalkeepers) with relative areas of 272, 175, and 73 m², where the large and medium areas obtained similar values among them in almost every variable, which were superior to the most reduced area. The relative areas proposed in our study were slightly inferior (154, 77, and 43 m²) but maintained the values as close as possible to the ones required by the competition (Fradua *et al.*, 2013). Despite this, superior values were demanded at those proposals played in larger spaces for most of the variables (Table 2 and Figure 2). Thus, for instance, the DC — the most representative value in general intensity during the activity (Casamichana and Castellano, 2010) — fluctuated between 94 m/min in RP, 103 m/min in SG, and 120 m/min in LG, being similar to the ones demanded for the competition only for the widest proposal (LG) (Casamichana *et al.*, 2012). The work-rest ratio values obtained in our research varied between 5 and 9.5, with these values always being superior to those proposals played at higher areas, slightly superior to the

ones demanded by semi-professional players in various SSG (3.5) (Casamichana *et al.*, 2012), and showing a possible increase of intensity in professional players at this kind of tasks (Dellal *et al.*, 2011).

The lack of differences in the HR response in our study, despite the different activity patterns within the three proposals, could be explained by the fact that the response in the HR not only depends on the running speed but on factors like jumps, turns, contacts, or psychological factors (Mendez-Villanueva *et al.*, 2013). This proves we need to take into account the HR along with certain physical responses at the tasks. On the other hand, the organisation and the number of working periods proposed at the SSG training is an important factor that should be considered when planning the training sessions (Dellal *et al.*, 2012). The structure we have outlined in our research was followed in the three proposals (four bouts of five min of duration, plus two min passive recovery) that allowed to examine if the design of the MSG had any influences in the physical and/or HR response throughout the successive working periods within the same session.

Just a few investigations have taken into account the changes in the physical and physiological variables throughout the successive working periods for different proposals of SSG (Dellal *et al.*, 2012; Dellal *et al.*, 2011). In our study, the HR response was quite stable in every proposal all along the series. Superior values of HR in P3, regarding P1, were reached only in RP. However, this possible tendency to increase the HR throughout these periods wasn't shown in P4 (Table 3). It's possible that this fluctuation in the response of the HR throughout the periods was conditioned by the largest tactic component of the task. Therefore, the physiological intensity in every period could depend on aspects such as the time spent possessing the ball, or the number of times the ball has been moved from one side of the playing field to another. None of the three proposals researched showed the tendency to increase the HR gradually throughout the periods; that date had been registered in previous investigations (Dellal *et al.*, 2012; Dellal *et al.*, 2011; Kelly and Drust, 2009). It's possible that the physiological differences among different periods were conditioned by the number of players participating per team, with larger differences for SSG involved in a smaller number of players per team (Dellal *et al.*, 2012). The physical response throughout these periods was quite stable both in RP and SG, with no differences between the variables DC, work/restratio, and distance/h covered in the speed zones higher than 13.0 Km/h (Table 3 and Figure 3). The differences only existed in Vmax at RP, with lower values in P1 (16.9 ± 0.9) than in P3 (17.8 ± 1.4). Thus, there was no evidence of fatigue throughout the periods in these two proposals. However, there were differences in proposal LG. The first periods showed higher values in DC, Vmax, and distance/h in the zones 7.0-12.9, 13.0-17.9, and 18.0-20.9 Km/h, and lower values in the zone <7.0 Km/h (Table 3 and Figure 3). These periods also showed a tendency throughout to reduce the distance at high speed and increase the distance at low speed. These data show an important finding in the investigation: the larger the playing areas the higher the physical demands. This provokes a loss of locomotive activity as repetitions go ahead and shows a possible "fatigue" effect that depends on the dimensions of the playing field. This possible "fatigue" effect is similar to the one described in previous studies (Dellal *et al.*, 2012), and it could be relevant when planning the training sessions.

CONCLUSIONS

The results of this study confirm the incidence of the dimensions of the playing field in the physical demands of the MSG with the same number of participant players, showing higher demands for the MSG performed in relative higher playing areas. There were no differences in HR response within the three proposals, though the high variability in the %HR_{max} and %HR_{res} in RP could advise against the use of this task when improving the aerobic endurance. The changes in the activity patterns, associated to the period of the exercise, could depend on the dimensions of the playing field. A possible "fatigue" effect in the main physical variables assessed was only observed in the proposal with a relative higher space (LG). Thus, depending on the aims

of the training sessions and the time within the season, coaches and fitness coaches could manage the playing areas and the way they prescribe the tasks when designing the MSG.

REFERENCES

1. Aslan A. (2013). Cardiovascular responses, perceived exertion and technical actions during small-sided recreational soccer: effects of pitch size and number of players. *J Hum Kinet*, 38, 95-105.
2. Bangsbo J, Iaia FM, Krstrup P. (2008). The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. *Sports Med*, 38(1), 37-51.
3. Barbero-Alvarez JC, Coutts A, Granda J, Barbero-Alvarez V, Castagna C. (2010). The validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes. *J Sci Med Sport*, 13(2), 232-235.
4. Casamichana D, Castellano J. (2010). Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: effects of pitch size. *J Sports Sci*, 28(14), 1615-1623.
5. Casamichana D, Castellano J, González-Morán A, García-Cueto H, García-López J. (2011). Physiological demand in small-sided games on soccer with different orientation of space. *Rev int cienc deporte*, 23, 141-154.
6. Casamichana D, Castellano J, Castagna C. (2012). Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. *J Strength Cond Res*, 26(3), 837-843.
7. Castellano J, Casamichana D, Dellal A. (2013). Influence of game format and number of players on heart rate responses and physical demands in small-sided soccer games. *J Strength Cond Res*, 27(5), 1295-1303.
8. Coutts AJ, Duffield R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports. *J Sci Med Sport*, 13(1), 133-135.
9. Dellal A, Da Silva CD, Hill-Haas S, Wong del P, Natali AJ., De Lima JR, Bara Filho MG, Marins JCB, Silami Garcia E, Chamari K. (2012). Heart rate monitoring in soccer: interest and limits during competitive match play and training, practical application. *J Strength Cond Res*, 26(10), 2890-2906.
10. Dellal A, Drust B, Lago-Penas C. (2012). Variation of activity demands in small-sided soccer games. *Int J Sports Med*, 33(5): 370-375.
11. Dellal A, Hill-Haas S, Lago-Penas C, Chamari K. (2011). Small-sided games in soccer: amateur vs. professional players' physiological responses, physical, and technical activities. *J Strength Cond Res*, 25(9), 2371-2381.
12. Dellal A, Jannault R, Lopez-Segovia M, Pialoux V. (2011). Influence of the Numbers of Players in the Heart Rate Responses of Youth Soccer Players Within 2 vs. 2, 3 vs. 3 and 4 vs. 4 Small-sided Games. *J Hum Kinet*, 28, 107-114.
13. Dellal A, Lago-Penas C, Wong del P, Chamari K. (2011). Effect of the number of ball contacts within bouts of 4 vs. 4 small-sided soccer games. *Int J Sports Physiol Perform*, 6(3), 322-333.
14. Dellal A, Owen A, Wong DP, Krstrup P, Van Exsel M, Mallo J. (2012). Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Hum Mov Sci*, 31(4), 957-969.
15. Drust B, Waterhouse J, Atkinson G, Edwards B, Reilly T. (2005). Circadian rhythms in sports performance—an update. *Chronobiol Int*, 22(1), 21-44.
16. Fradua L, Zubillaga A, Caro O, Ivan Fernandez-Garcia A, Ruiz-Ruiz C, Tenga A. (2013). Designing small-sided games for training tactical aspects in soccer: extrapolating pitch sizes from full-size professional matches. *J Sports Sci*, 31(6), 573-581.

17. Helgerud J, Engen LC, Wisloff U, Hoff J. (2001). Aerobic endurance training improves soccer performance. *Med Sci Sports Exerc*, 33(11), 1925-1931.
18. Hill-Haas SV, Coutts AJ, Rowsell GJ, Dawson BT. (2009). Generic versus small-sided game training in soccer. *Int J Sports Med*, 30(9), 636-642.
19. Hill-Haas SV, Dawson BT, Coutts AJ, Rowsell GJ. (2009). Physiological responses and time-motion characteristics of various small-sided soccer games in youth players. *J Sports Sci*, 27(1), 1-8.
20. Impellizzeri FM, Marcora SM, Castagna C, Reilly T, Sassi A, Iaia FM, Rampinini E. (2006). Physiological and performance effects of generic versus specific aerobic training in soccer players. *Int J Sports Med*, 27(6), 483-492.
21. Karvonen MJ, Kentala E, Mustala O. (1957). The effects of training on heart rate; a longitudinal study. *Ann Med Exp Biol Fenn*, 35(3), 307-315.
22. Kelly DM, Drust B. (2009). The effect of pitch dimensions on heart rate responses and technical demands of small-sided soccer games in elite players. *J Sci Med Sport*, 12(4), 475-479.
23. Little T, Williams AG. (2007). Measures of exercise intensity during soccer training drills with professional soccer players. *J Strength Cond Res*, 21(2), 367-371.
24. Mendez-Villanueva A, Buchheit M, Simpson B, Bourdon PC. (2013). Match play intensity distribution in youth soccer. *Int J Sports Med*, 34(2), 101-110.
25. Owen AL, Wong DP, Paul D, Dellal A. (2014). Physical and Technical Comparisons between Various-Sided Games within Professional Soccer. *Int J Sports Med*, 35(4), 286-292.
26. Rampinini E, Impellizzeri FM, Castagna C, Abt G, Chamari K, Sassi A, Marcora SM. (2007). Factors influencing physiological responses to small-sided soccer games. *J Sports Sci*, 25(6), 659-666.
27. Randers MB, Mujika I, Hewitt A, Santisteban J, Bischoff R, Solano R, Zubillaga A, Peltola E, Krstrup P, Mohr, M. (2010). Application of four different football match analysis systems: a comparative study. *J Sports Sci*, 28(2), 171-182.
28. Turner AN, Stewart PF. (2014). Strength and conditioning for soccer players. *Strength Cond J*, 36(4), 1-13.