IMPROVEMENT OF THE PHYSICAL CONDITIONING OF YOUNG SOCCER PLAYERS BY PLAYING SMALL-SIDED GAMES ON DIFFERENT PITCH SIZE – SPECIAL REFERENCE TO PHYSIOLOGICAL RESPONSES

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Abstract:

The purpose of this study was to investigate whether young soccer players change their physiological responses according to the different sizes of a pitch for 3-a-side and 4-a-side games (SSG). Sixteen young soccer players (age 14.2±0.6 yrs; height 162.8±5.7 cm; body mass 55.1±7.4 kg) participated in three different formats of 3-a-side (small pitch size: SSG_S, 20x15 m; medium pitch size: SSG_M, 25x18 m; large pitch size: SSG_L, 30x20 m) and 4-a-side (SSG_S, 20x20 m; SSG_M, 30x20 m; SSG_L, 32x25 m) games. Each player performed the Yo-Yo intermittent recovery test (YIRT) level 1. Then, the 3-a-side and 4-a-side games were organized in random order at 2-day intervals. During SSG, heart rate (HR) was recorded. In addition, the rating of perceived exertion (RPE) was determined at the end of each SSG. The study results demonstrated that young soccer players presented significantly higher HR ($F=14.722$; $p<.05$; $\eta^2=0.495$), %HRmax ($F=14.694$; $p<.05$; $\eta^2=0.495$) and RPE_{10} ($F=14.045$; $p<.05$; $\eta^2=0.484$) during 3-a-side SSG_L compared to both 3-a-side SSG_S and SSG_M. Moreover, the 4-a-side SSG_L induced significantly higher HR ($F=6.658$; $p<.05$; $\eta^2=0.307$), %HRmax ($F=6.495$; $p<.05$; $\eta^2=0.302$) and RPE_{10} ($F=18.719$; $p<.05$; $\eta^2=0.555$) compared to 4-a-side SSG_S. Therefore, it can be concluded that young soccer players could change their physiological responses during SSGs according to a different pitch size. The results of this study suggest that coaches of young soccer players should pay special attention to choosing the SSG type and pitch size when targeting physical conditioning of players in soccer training.

Key words: *soccer, aerobic endurance, youth soccer players, fitness training*

Introduction

In recent years, coaches often use small-sided games (SSG) in soccer instead of the traditional interval training to develop the technical, tactical and physical characteristics of their players in the same training unit (Impellizzeri, et al., 2006; Dellal, et al., 2008). It is especially the case in young soccer players but to the best of our knowledge, few studies have attempted to investigate the impact of SSG on young players. The majority of the findings regard adult players although fitness conditioning is also age-dependent (Philippaerts, et al, 2006; Wong & Wong, 2009). Previous studies have shown that several factors such as the number of players and the pitch size (Koklu, Asci, Kocak, Alemdaroglu, & Dundar, 2011b; Dellal, Jannault, Lopez-Segovia, & Pialoux, 2011a; Abrantes, Nunes, Maçãs, Leite, & Sampaio, 2012), bout duration (Fanchini, et al., 2010), game rules (Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Dellal, Logo-Penas, Wong, & Chamari, 2011b), coach encouragement (Rampinini, et al., 2007), team formation (Koklu, Ersoz, Alemdaroglu, Asci, & Ozkan, 2012) and training regime (Hill-Haas, Rowsell, Dawson, & Coutts, 2009b; Koklu, 2012) affect players' activities during SSG.

Dellal et al. (2011a) demonstrated that the heart rate (HR) responses were higher during 2-a-side (80.1±3.6%, $p<.001$) and 3-a-side games

(81.5±4.3%, p<.001) compared to 4-a-side games (70.6±5.9%) in 16.5±0.5 year-old youth players. The pitch ratio per player (pitch area divided by the number of players) used in this study was 125 m^2 for the 2-a-side and the 3-a-side games and 122.5 m^2 for the 4-a-side games, respectively. In the research done on 16.6±0.5 year-old players Koklu (2012) demonstrated that a 3-a-side SSG (72 m^2 per player) induced significantly higher HR responses than both the 2-a-side (75 m^2 per player) and the 4-a-side (108 m^2 per player) games, whereas greater blood lactate values were found after the 2-a-side games. Katis and Kellis (2009) investigated the effects of SSG on physical conditioning of soccer players 13.0±0.9 old. They found that the decrease of the number of players (3-a-side vs. 6-a-side games) induced greater HR responses and technical actions (short passes, tackles, dribbles and scoring) according to Platt, Maxwell, Horn, Williams, and Reilly (2001). Complementarily, they revealed a greater alteration of explosiveness (30 m sprint and horizontal jump) after the 3-a-side games. Hill-Haas, Dawson, Coutts and Rowsell (2009a) examined the acute physiological responses associated with three different SSG formats of 2-a-side, 4-a-side and 6-a-side games in youth players. Their results showed that, as SSG formats decrease in size and relative pitch area remains constant (150 m^2 per player), overall physiological and perceptual workload increases.

Although it is a key factor in order to determine the desired intensity, there are just two studies which investigated the effects of pitch size on the physiological responses of young soccer players in SSG (Hill-Haas, et al., 2009a; Casamichana & Castellano, 2010). However, in these studies, players performed only a continuous (24 minutes) (Hill-Haas, et al., 2009a) or very long interval format (8 minutes) (Casamichana & Castellano, 2010) which is not commonly used in SSG training sessions. In addition, in adults, Rampinini et al. (2007) reported that the size of the pitch should be taken into account when planning training drills, as it influences the exercise intensity and the motor response of players during SSG. Owen, Twist and Ford (2004) showed that enlarging the pitch size used for the SSG by ten meters generally caused increases of mean and peak HR throughout the SSG. On the other hand, Kelly and Drust (2009) found that the impact of changes in pitch size did not alter HR responses and technical requirements within 4-a-side games of adult players. Moreover, Tessitore, Meeusen, Piacentini, Demarie, and Capranica (2006) examined the acute physiological responses associated with two pitch sizes (30x40 m and 50x40 m) of 6-a-side games in adult soccer players. Their results indicated that the smaller pitch size had a large impact on the metabolic demands of exercise. Clearly, the physiological responses, technical activity and time-motion characteristics vary with pitch size in adult soccer players (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Dellal, et al, 2008).

In this context, although the physiological impact of pitch size was widely examined in adult players, no studies take into account the age and have attempted to investigate it in young soccer players. Therefore, the aim of the present study was to examine the acute effects of the pitch size on the physiological responses of young soccer players during the two most traditional SSG (i.e. 3-a-side and 4-a-side) commonly used. It is hypothesized that the increase of the pitch size induces greater physiological responses. Coaches will be helped about which pitch size should be used to achieve the appropriate exercise intensity to improve the aerobic endurance in young soccer players.

Methods

Subjects

Sixteen young soccer players (average age 14.2±0.6 yrs; height 162.8±5.7 cm; body mass 55.1±7.4 kg; training experience 5.5±1.4 yrs; HR_{max} 201.7±3.0 beat·min^{-1}) voluntarily participated in this study. All the players were members of the same youth team competing in an elite academy league. Written informed consent was obtained from all the subjects and their parents. All players and parents were notified of the research procedures, requirements, benefits, and risks before giving informed consent. The study was approved by the local Ethics Committee, and was conducted in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki.

Procedures

The 5-week pre-season training period served as a familiarization period for the participants to the SSG formats and to the Yo-Yo intermittent recovery test level 1 (YIRT). At the end of the pre-season training period, players underwent the YIRT and were ranked according to the distance covered in this test. The ranking system worked as follows: players who covered the least distance were given a score of 1 and those who covered the most ground were awarded a score of 5 (Hill-Haas, et al., 2009a; Casamichana & Castellano,2010; Koklu, 2012a). The coach also provided an overall subjective technical/tactical skill level for each player using a 5-point scale (from 1 "below average" to 5 "outstanding"). The total score for each player was the sum of their technical/tactical skill and YIRT scores (Hill-Haas, et al., 2009a; Casamichana & Castellano, 2010; Koklu, 2012). In an attempt to avoid skill and fitness mismatches and a consequent

imbalance in the opposing SSG teams, each SSG team was then balanced in terms of the players' skill and fitness rankings (Koklu, et al., 2012).

The study was conducted over a two-week period. On the first day, anthropometric measurements (height and body mass) were taken for each player; this was followed by the YIRT. The HR_{max} for each player was determined during the YIRT. Then SSG consisting of four bouts were organized. Two-minute passive recovery periods were given between the bouts of SSG. A 20-minute warm-up was standardized and identical for all SSG and it consisted of low intensity running, striding, and active stretching. During the SSG, HR responses were recorded. In addition, the rating of perceived exertion (RPE) was determined after the end of the last bout of each SSG (immediately after the end of the SSG). The YIRT and SSGs were performed on a synthetic grass pitch at a similar time of the day between six and eight p.m. in order to have similar chronobiological characteristics (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005).

The Yo-Yo intermittent recovery test (YIRT) level 1

The YIRT level 1 consists of repeated 20-meter runs back and forth between the starting, turning, and finishing lines, and at a progressively increased speed, which is controlled by audio bleeps from a tape recorder. The tape (YO-YO tests, HO + Strom, Denmark) was calibrated prior to every trial and procedures were identical to that previously described by Bangsbo, Iaia, and Krustrup (2008). The test was performed on a synthetic grass field in groups of six players, as suggested by Bangsbo et al. (2008). Each player's HR was measured at 5-second intervals throughout the test and stored using Polar S810 HR monitors (Polar Electro OY, Kempele, Finland). Stored data were transferred to the computer and filtered by Polar Precision Performance Software™ (PPP4, Finland). The highest HR measurement during the test was recorded as Yo-Yo HRmax (Krustrup, et al., 2003).

Small-sided games

Table 1 shows the number of bouts, bout duration (min), rest interval between the bouts (min), pitch dimension (length x width), and relative pitch size (m^2) for the SSG. The SSG were performed with four supporting players situated outside the playing area, with the instruction to maintain collective possession of the ball for as long as possible, goalkeepers did not participate in the SSGs. To ensure that the game would restart immediately if the ball left the field of play, spare balls were kept all a round the pitch. Rampinini et al. (2007) showed that coach encouragement positively effects players' physiological responses during the SSG. Therefore, the coaches continually offered verbal encouragement to the players during the games. Players were allowed to consume available drinking water during the recovery periods of each bout during the SSG.

Heart rate monitoring

Heart rate was recorded at 5-second intervals during SSG bouts using short-range radio telemetry (Polar Team Sport System, Polar Electro Oy, Kempele, Finland). Exercise intensities during SSG bouts were assessed using HR, expressed as a percentage of HR_{max} measured in the YIRT test. The HR was stored by Polar S810 HR monitors throughout the games and transferred to the computer and filtered by Polar Precision Performance Software™ (PPP4, Finland). The mean HR for the SSG was calculated by taking the means of the four bouts played (in % of HR_{max}).

Rating of perceived exertion (RPE)

The CR-10 rating of the perceived exertion scale proposed by Foster et al. (2001) was presented to each player at about two minutes after the completion of the last bout of the SSG. All players were informed about and familiarized with the CR-10 scale before the SSG. This scale has been validated as an indicator of the training intensity in the intermittent tasks of SSG (Coutts, Rampinini, Marcora, Castagna, & Impellizzeri, 2009).

Table 1. Small-sided games characteristics

	3-a-side			4-a-side		
	SSG_S	SSG_M	SSG_L	SSG_S	SSG_M	SSG_L
Number of bouts	4	4	4	4	4	4
Bout duration (min)	3	3	3	4	4	4
Rest interval between the bouts (min)	2	2	2	2	2	2
Pitch dimension (length x width) (m x m)	20x15	25x18	30x20	20x20	30x20	32x25
Relative pitch size (m^2)	50	75	100	50	75	100

SSG_S: small pitch size games; SSG_M: medium pitch size games; SSG_L: large pitch size games

Statistical analysis

All data are reported as means and standard deviations. Before using the parametric tests, the assumption of normality was verified using the Shapiro-Wilks test. A one-way repeated-measures analysis of variance (ANOVA) was performed on each dependent variable, including heart rate, $\%HR_{max}$ and RPE. A Bonferroni *post-hoc* test was applied to make a pairwise comparison between different pitch sizes. The level of statistical significance was set at $p<.05$. Effect sizes (η^2) were also calculated for physiological responses.

Results

Table 2 shows the average HR, $\%HR_{max}$, and RPE_{10} responses of the players to the different pitch sizes of 3-a-side games. The study results demonstrated that the large-size 3-a-side game induced significantly higher HR ($F=14.722$; $p<.05$; $\eta^2=0.495$), $\%HR_{max}$ ($F=14.694$; $p<.05$; $\eta^2=0.495$) and RPE_{10} ($F=14.045$; $p<.05$; $\eta^2=0.484$) compared to both the small and medium pitch size 3-a-side games (Table 2). In addition, a medium pitch size 3-a-side game induced significantly higher HR and $\%HR_{max}$ than the small pitch size 3-a-side game.

Furthermore, results showed that the large pitch size 4-a-side game induced significantly higher HR ($F=6.658$; $p<.05$; $\eta^2=0.307$), $\%HR_{max}$ ($F=6.495$; $p<.05$; $\eta^2=0.302$) and RPE_{10} ($F=18.719$; $p<.05$; $\eta^2=0.555$) compared to the small pitch size 4-a-side game (Table 3). In addition, the large pitch size 4-a-side game induced significantly higher RPE_{10} than the medium pitch size 4-a-side game.

Table 2. Comparison of the physiological responses to different pitch sizes of the 3-a-side games

	SSG_S	SSG_M	SSG_L
HR (beat·min^{-1})	176.3±2.5 [a, c]	180.1±5.5 [b]	184.2±6.5
%HRmax	87.1±1.6 [a, c]	89.0±2.3 [b]	91.0±2.5
RPE_{10}	5.2±0.5 [a]	5.6±0.5 [b]	6.1±0.6

[a]Significant difference between SSG_L and SSG_S, $p<.05$; [b]Significant difference between SSG_L and SSG_M, $p<.05$; [c]Significant difference between SSG_M and SSG_S, $p<.05$; HR: heart rate; $\%HR_{max}$: percentage of maximum heart rate; RPE: rating of perceived exertion; SSG_S: small pitch size games; SSG_M: medium pitch size games; SSG_L: large pitch size games

Table 3. Comparison of physiological responses to different pitch sizes of the 4-a-side games

	SSG_S	SSG_M	SSG_L
HR (beat·min^{-1})	175.0±7.7 [a]	179.9±7.9	183.5±8.4
% HRmax	86.5±4.0 [a]	88.9±3.2	90.7±3.0
RPE_{10}	4.4±0.5 [a]	5.0±0.4 [b]	5.3±0.5

[a]Significant difference between SSG_L and SSG_S, $p<.05$; [b]Significant difference between SSG_L and SSG_M, $p<.05$; HR: heart rate; $\%HR_{max}$: percentage of maximum heart rate; RPE: rating of perceived exertion; SSG_S: small pitch size games; SSG_M: medium pitch size games; SSG_L: large pitch size games

Discussion and conclusions

The purpose of this study was to investigate the effects of the pitch size on the physiological responses of young soccer players during 3-a-side and 4-a-side games (SSG). The main findings show that enlarging the pitch size does have an influence on HR, % HR_{max} and RPE_{10} responses of 3-a-side and 4-a-side games in young soccer players.

This study indicated that 3-a-side and 4-a-side SSG_L induced significantly higher HR and $\%HR_{max}$ responses compared to both SSG_M and SSG_S in young soccer players except for the 4-a-side SSG_M. Although, in HR and $\%HR_{max}$ responses, there was no significant difference between 4-a-side SSG_M and SSG_L, higher HR and $\%HR_{max}$ responses were observed in the 4-a-side SSG_L than in the 4-a-side SSG_M. In addition, 3-a-side and 4-a-side SSG_M induced higher HR and $\%HR_{max}$ responses compared to SSG_S. These findings indicate that when the pitch size per player is increased, the HR and $\%HR_{max}$ responses are increased. The reason is that the increase in relative pitch size might cause players to cover a greater distance in a game played with and without the collective ball possession. When the pitch size increases, the pitch ratio per player is greater and thus it increases the run distance and necessity to be constantly in movement. Therefore players manifested higher HR and HR_{max} responses in SSG_L than both in SSG_M and SSG_S. This finding is similar to the results of the study of Casamichana and Castellano (2010). They revealed that when the individual playing area was larger, the effective playing time, the percent maximum heart rate, percent mean heart rate, time spent above 90% maximum heart rate and the rating of perceived exertion were all higher. In addition, Owen et al. (2004) demonstrated that as the pitch size became larger by ten meters, but the player numbers remained constant, mean heart rates generally increased in professional soccer players. Moreover, Rampinini et al. (2007) examined the effects of pitch dimensions (small, medium and large) on exercise intensity in three-, four-, five-, and six-a-side games in adult soccer players. They demonstrated that small-sided games played on a larger pitch were more intense than the same drills played on smaller pitches.

However, pitch size and the increase of pitch ratio per player during SSG had not only an effect on HR and $\%HR_{max}$ responses, but also on RPE_{10} responses. The present study also demonstrated that 3-a-side and 4-a-side SSG_L induced significantly higher RPE_{10} responses compared to both SSG_M and SSG_S. In addition, 3-a-side and 4-a-side SSG_M induced higher RPE_{10} responses compared to SSG_S. These findings indicate that relative pitch size may

be the reason for RPE_{10} responses. When the pitch size per player is increased, the RPE_{10} responses might be increased. Similarly, Rampinini et al. (2007) demonstrated that small-sided games played on a larger pitch induced higher RPE responses than the same drills played on smaller pitches. Parallel to the present study results, Casamichana and Castellano (2010) reported that significant lower RPE responses were observed during small-pitch 5-a-side games compared to both the large and medium-pitch 5-a-side games. The increase of pitch ratio per player induced higher HR response and RPE values probably due to the increase of running distance, the greater activity, the reduction of recovery period within the SSG and the fact that players were systematically more stimulated.

In conclusion, the present study showed that enlarging pitch size does have an influence on HR, % HR_{max} and RPE_{10} responses of 3-a-side and 4-a-side games in young soccer players. Therefore, it can be concluded that an increased pitch size per player results in increased physiological responses during SSG. The results of this study suggest that coaches should pay attention to choosing the SSG type and pitch size per player when improving physical condition of young soccer players in soccer training. In addition, SSG_M and SSG_L are better in order to have a physiological impact and aerobic solicitation with greater long passes combined with short passes, whereas SSG_S impose greater technical difficulty and greater anaerobic solicitation (increase in the number of deceleration, acceleration and directional changes). Moreover, for coaches who want higher physiological responses from their young players, SSG_L should be organized. Finally, the periodization of the training exercises including SSG have to be precisely planned in youth soccer players and it is essential that coaches link the pitch size effects with the technical, physical and tactical needs and objectives.

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UNAPREĐENJE KONDICIJSKE PRIPREMLJENOSTI MLADIH NOGOMETAŠA IGRANJEM MALOG NOGOMETA NA IGRALIŠTIMA RAZLIČITIH VELIČINA

Cilj je ovog istraživanja bio utvrditi da li mladi nogometaši različito fiziološki odgovaraju na igranje malog nogometa 3 na 3 i 4 na 4 kada se mijenja veličina igrališta. Šesnaest mladih nogometaša (14,2±0,6 godina, tjelesne visine 162,8±5,7 cm i tjelesne težine 55,1±7,4 kg) igralo je mali nogomet 3 na 3 na tri različite veličine igrališta (malo igralište: SSG_S, 20x15m; srednje igralište: SSG_M, 25x18m; veliko igralište: SSG_L, 30x20m) te 4 na 4 na (SSG_S, 20x20m; SSG_M, 30x20m; SSG_L, 32x25m). Svaki igrač je bio testiran pomoću *YoYo intermittent recovery testa* (YYIRT) 1. razine. Nakon provedenih testiranja, slučajnim redoslijedom, u intervalima od 2 dana, igrao se mali nogomet 3 na 3 i 4 na 4. Tijekom igranja malog nogometa bilježena je frekvencija srca (FS). Nadalje, nakon posljednjeg perioda svake igre zabilježena je i subjektivna procjena opterećenja (SPO). Rezultati istraživanja pokazali su da mladi nogometaši manifestiraju značajno višu frekvenciju srca ($F=14,722$; $p<,05$; $\eta^2=0,495$), %FS ($F=14,694$; $p<,05$; $\eta^2=0,495$) i SPO_{10} ($F=14.045$; $p<,05$; $\eta^2=0,484$) tijekom igranja 3 na 3 na velikom igralištu u odnosu na igranje 3 na 3 na srednjem i malom igralištu. Štoviše, igranje 4 na 4 na velikom igralištu izazvalo je značajno višu frekvenciju srca ($F=6,658$; $p<,05$; $\eta^2=0.307$), $\%FS_{max}$ ($F=6,495$; $p<,05$; $\eta^2=0,302$) i SPO_{10} ($F=18,719$; $p<,05$; $\eta^2=0,555$) u usporedbi s igranjem 4 na 4 na malom igralištu. Stoga se može zaključiti da mladi nogometaši manifestiraju različite fiziološke odgovore na igranje malog nogometa na igralištima različitih veličina. Rezultati ovog istraživanja sugeriraju da bi treneri koji rade s mladim nogometašima trebali obratiti pažnju na odabir broja igrača i veličinu igrališta u odnosu na broj igrača kako bi poboljšali razinu kondicijske pripremljenosti tijekom nogometnog treninga.

Ključne riječi: *nogomet, aerobna izdržljivost, mladi nogometaši, kondicijski trening*