Paper : Training

The Effect of Small Size Court on Physical and Technical Performances in Trained Youth Soccer Players

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The aim of the present study was to compare physical and technical performances during 11-a-side matches (11M) and 6-a-side small-sided games (SGs) with various pitch sizes in trained young soccer players. Ten outfield players (age = 16.2 ± 0.6 years) performed 11M (area per player = 325 m^2) and SGs with three different pitch sizes (area per player = 325 (SGL), 165 (SGM) and 81 (SGS) m^2). A Global Positioning System (15 Hz) and video recording were employed to analyse physical and technical performances, respectively. Total distance covered was significantly longer during 11M than SGM and SGS, and high speed running distance was significantly greater during 11M than SGS ($P < 0.05$ for all). A greater acceleration frequency (1-2 and 2-3 $m \cdot s^{-2}$) was observed during SGS compared to 11M ($P < 0.05$). A significantly less number of shots was attempted during 11M than SGM and SGS, and the number of tackles, touches and passes, and ball involvement were significantly less during 11M than SGS ($P < 0.05$ for all). Therefore, SGs can provide similar physical and technical stimulus to 11M as long as area per player is similar. Whereas, a reduction in area per player of SGs in comparison with 11M results in less running distances, and greater acceleration frequency and technical demands during SGs compared to 11M.

Keywords: Acceleration, Association football, GPS technology, Motion analysis

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1. Introduction

In soccer, small-sided games (SGs) are commonly employed by coaches to improve physical fitness (Hill-Haas et al., 2009a; Impellizzeri et al., 2006) or technical and tactical abilities (Jones and Drust, 2007; Reilly, 2005) of players depending on the coaches' philosophy (Halouani et al., 2014). A large number of studies have been conducted to investigate the variables which influence physical and technical demands of SGs (Hill-Haas et al., 2011). These variables include pitch size (Casamichana and Castellano, 2010; Rampinini et al., 2007), player number (Aguir et al., 2013; Hill-Haas et al., 2009b), coach encouragement (Rampinini et al., 2007), training regimen (continuous or interval) (Casamichana et al., 2013), rule modifications (Hill-Haas et al., 2010) and use of goals and/or goalkeepers (Castellano et al., 2013).

Given that the modifications of player number and pitch size have been shown to influence physical and technical demands of soccer play in SGs (Aguir et al., 2013; Casamichana and Castellano, 2010; Hill-Haas et al., 2009b; Rampinini et al., 2007), demands of 11-a-side matches (11M) have only been compared to SGs with various number of players per team whilst the pitch size or area per player was fixed (Casamichana et al., 2012; Gabbett and Mulvey, 2008). It has been argued that an inclusion of frequent match specific activities in SGs makes the training stimulus more specific to the demands of actual match play and increases the efficiency of training (Rampinini et al., 2007). Hence, there is a necessity to compare demands of 11M and SGs with various area per player to investigate differences and similarities between 11M and SGs. Such information would support coaches to select SGs with an appropriate pitch size depending on the aim of training sessions.

Another issue in the previous studies is that, some of literatures which compared demands of 11M and SGs only estimated physical performance with just distances covered in particular speed zones (Casamichana et al., 2012; Gabbett and Mulvey, 2008). Focusing on just distances covered at constant

speeds neglects an importance of accelerations. Accelerations require a greater neural activation to the working muscles and a higher rate of force production compared to a constant speed running, and is a precursor to running at high speeds (Mero and Komi, 1987; Osgnach et al., 2010). Even in running at low speeds, a high metabolic load is imposed on soccer players when acceleration is elevated and acceleration will substantially contribute to the physical demands of soccer (Osgnach et al., 2010). Moreover, only one study has compared technical demands of 11M and SGs (Gabbett and Mulvey, 2008). Thus, it is important to compare physical and technical demands of 11M and SGs, and the physical demands should be estimated with a method which takes account of accelerations.

Lastly, the previous studies only recruited adult players that there is a lack of comparative data between 11M and SGs in young soccer players (Casamichana et al., 2012; Gabbett and Mulvey, 2008). The young players who are in developing stages should not be considered as miniature adults and hence training programmes should be specifically designed for the young players (Reilly et al., 2000). Investigating differences and similarities in physical and technical demands between 11M and SGs in young players may support coaches and sports scientists to prepare training sessions which are specific to the age and ability of the players.

Therefore, the aim of the present study was to compare physical and technical performances including accelerations during 11M and SGs with various pitch sizes in young soccer players.

2. Methods

2.1. Participants

The participants were ten outfield players from the same soccer team who competed in a regional level competitions (age = 16.2 ± 0.6 years; height = 170.0 ± 6.4 cm; body mass = 59.6 ± 7.5 kg; playing experience = 6.0 ± 1.3 years) and there were four central defenders, two defensive midfielders, two attacking midfielders and two strikers. The team trained five times and played one match in a week, and all trainings were technical sessions. Participants were provided with a written and verbal explanation of the study including experimental protocols and all measurements to be taken. Each player signed an informed assent form and completed a health screen questionnaire prior to participation in the study. Each player's parent signed a consent form prior to the start of the study. Players were free to withdraw from the study without giving any reasons. The study was approved by a University Ethical Committee.

2.2. Performance analysis

The participants performed 11M and 6-a-side (five field players and a goalkeeper per team) SGs with three different pitch sizes (large SG (SGL), medium SG (SGM), small SG (SGS)). The participants were separated into two groups and they competed against each other during 11M and SGs. In SGs, each team contained two central defenders, a defensive midfielder, an attacking midfielder and a striker, and the participants played their natural playing positions during 11M and SGs. The players included in each team were fixed for all 11M and SGs but there was a maximum of one player difference per team in some sessions due to injuries. The players in each team were selected by the coach and he was asked to include players with similar ability to balance the strength of the teams.

All data collection took place on a new generation synthetic astroturf (Grand Grass F-M DS, Mizuno corporation, Osaka, Japan). Pitch dimension, playing area, area per player are summarised in **table 1**. Goals used in all 11M and SGs were official size (7.32 x 2.44 m) which was stated in Laws of the game (The Fédération Internationale de Football Association (FIFA)). Pitch length-to-width ratio was almost the same between all 11M and SGs. Area per player of 11M and SGL are the same and area per player of SGM and SGS is roughly a half and quarter of 11M, respectively. These pitch sizes were selected to provide a similar ratio of area per player between SGL and SGM and between SGM and SGS. Because a previous study which compared physical and technical performances of SGs with three different pitch sizes did not reduce pitch sizes with the same ratio (e.g., area per player of SGM was 64% of SGL and area per player of SGS was 42% of SGM) (Casamichana and Castellano, 2010). The Laws of the game (FIFA) was applied during 11M and SGs but offside rule was neglected during the SGs. No other rule modifications were included during 11M and SGs. Each of 11M and SGs were conducted four

Table 1 Established characteristics of 11M and SGs.

	11M	SGL	SGM	SGS
Length (m)	105	78	55	39
Width (m)	68	50	36	25
Playing area (m^2)	7140	3900	1980	975
Area per player (m^2)	325	325	165	81
Duration (min)	35	35	35	35
Goalkeepers	Yes	Yes	Yes	Yes
Offside rule	Yes	No	No	No

Note: 11M = 11-a-side matches; SGL = large small-sided games; SGM = medium small-sided games; SGS = small small-sided games.

times during six weeks and two to three sessions took place in a week. They were conducted in a counterbalanced order and a day after a match was avoided. All participants took part in each of 11M and SGs for at least twice (2.8 ± 0.8 recordings). Each session started with a 30 minute warm up which involved static and dynamic stretches, running at various speeds from jogging to sprinting and technical drills. Duration of all 11M and SGs were 35 minutes because that was the duration of a half of participants' official matches. All 11M and SGs were continued for 35 minutes without intervals. The coach was providing verbal encouragement to the players throughout 11M and SGs. Ball persons were placed around the pitch to minimise non-playing time and verbal encouragement was given by the coach during 11M and SGs. Temperature was between 23 and 28 ºC and humidity was between 64 and 88% during the data collection and rainy days were avoided.

All 11M and SGs were analysed using a 15 Hz Global Positioning System (GPS) (SPI HPU, GPSport, Australia) and speed zones were calculated based on the method created by Goto and colleagues (2015). The speed zones were walking (0.0-1.1 $m \cdot s^{-1}$), jogging (1.2-2.2 $m \cdot s^{-1}$), low speed running (2.3-3.4 $m \cdot s^{-1}$), moderate speed running (3.4-4.5 $m \cdot s^{-1}$) and high speed running (> 4.5 $m \cdot s^{-1}$) (squad speed zone, Goto et al., 2015). Accelerations were separated into three zones and they were 1-2, 2-3 and > 3 $m \cdot s^{-2}$. To be included in the analysis, acceleration had to stay in a particular zone for at least one second. Acceleration frequency and distance covered whilst accelerating were estimated. The GPS was accessing seven to ten satellites throughout the data collection. The distances covered in each speed zone and acceleration zone were calculated using Team AMS software version 3.8.3 (GPSport, Australia). The participants wore a heart rate (HR) monitor during all 11M and SGs, and HR was recorded every five seconds (T38 heart rate transmitter, Polar electro ltd, Finland). Percentage of mean and maximum HR ($\%HR_{mean}$ and $\%HR_{max}$) were calculated respect to the maximum heart rate estimated by the age-predicted HRmax equation (i.e., 220 – age) (Wilmore and Costill, 1999). All 11M and SGs were recorded from a height of 30 m and 13 m away from the pitch using video camera (HC-V360M, Panasonic, Osaka, Japan) and participants' technical performance was analysed afterwards with Prozone match insight (Prozone Sports Ltd, Leeds, the UK). The technical events included in the analyses were: tackle (dispossession or attempted dispossession of an opponent by physical challenge or pressure when actual challenge/tackle is attempted); block (an opposing player, in close proximity, prevents the ball from reaching its intended target); touch (any touch other than a pass, shot, tackle etc taken by a player with any part of his body except his head); pass; header; shot; dribble; goal; and ball involvement (total of all technical activities analysed).

2.3. Statistical analyses

Normality of the data was examined using Shapiro-Wilk test and Homogeneity of variance was verified with Levene's Test. One way analysis of variance with Tukey post hoc test was used to compare match performance between 11M and three SGs. The level of statistical significance was set at $p < 0.05$. Results are presented as mean ± standard deviation (SD) and IBM SPSS 22.0 was used for all the statistical analyses.

3. Results

3.1. Outcomes and goals from matches and small-sided games

Outcomes from all 11M and SGs were eight wins,

six losses and two draws for a team and the team scored 108 goals. The other team scored 84 goals.

3.2. Physical performance

Table 2 shows physical performance during 11M and SGs. There were no differences in total distance covered during 11M and SGL. However, total distance covered lessened as the area per player was reduced and total distance covered during 11M was roughly 15% and 30% longer than SGM and SGS, respectively ($p < 0.01$ for all). During 11M, more than four times greater distance was covered by high speed running compared to SGS ($P < 0.01$). Whereas, high speed running distance during 11M was about 30% shorter than that of SGL ($P < 0.01$). Moreover, peak speed was around 10% faster during 11M compared to SGS ($P < 0.01$). The number of accelerations (1-2 $m \cdot s^{-2}$) was roughly 30% less during 11M compared to SGS ($P < 0.01$) and the number of accelerations (2-3 $m \cdot s^{-2}$) was approximately 40% less during 11M compared to SGS ($P < 0.05$). There were no significant differences between 11M and SGs in $\%HR_{mean}$ and $\%HR_{max}$.

3.3. Technical performance

Table 3 illustrates technical performance during 11M and SGs. The number of tackles was 60% higher during SGS compared to 11M ($P < 0.05$). The number of touches was approximately 130% greater during SGS ($P < 0.01$) compared to 11M. For the number of passes, roughly 60% greater attempts were made during SGS than 11M ($P < 0.01$). Compared to 11M, four times or greater number of shots were performed during SGM ($P < 0.05$) and SGS ($P < 0.01$). The ball involvement was around 60% greater during SGS compared to 11M ($P < 0.01$).

4. Discussion

This is the first study that compared physical and technical performances during 11-a-side matches and small-sided games with various pitch sizes in trained young soccer players. The main findings of the present study were that: 1) both physical and technical performances during 11M and SGs are similar as long as area per player is similar; 2) a reduction in area per player of SGs in comparison with 11M provides less total running distance, high speed running

Table 2 Physical performance during 11M and SGs.

	11M		SGL		SGM		SGS	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total distance (m)	4070^{b*c*}	337	4119^{b*c*}	285	3538^{c}	360	3062	324
Total distance ($m \cdot min^{-1}$)	116^{b*c*}	10	118^{b*c*}	8	101^{c}	10	87	9
High speed running distance (m)	308^{a*c*}	100	472^{b*c*}	93	235^{c*}	65	73	22
High speed running distance ($m \cdot min^{-1}$)	9^{a*c*}	3	13^{b*c*}	3	7^{c*}	2	2	1
High speed running frequency	53^{a*c*}	16	74^{b*c*}	16	44^{c*}	12	17	6
Peak speed ($m \cdot s^{-1}$)	6.8^{c*}	0.5	7.2^{c*}	0.3	6.8^{c*}	0.2	6.0	0.4
Number of accelerations (1-2 $m \cdot s^{-2}$)	87^{c*}	23	100^{c}	22	107	22	128	25
Number of accelerations (2-3 $m \cdot s^{-2}$)	20^{c}	7	26	8	29	8	36	17
Number of accelerations (> 3 $m \cdot s^{-2}$)	4	2	5	3	6	3	5	6
Acceleration distance (1-2 $m \cdot s^{-2}$)	496	121	573^{c}	109	517	108	441	90
Acceleration distance (2-3 $m \cdot s^{-2}$)	121	38	138	31	156	38	149	45
Acceleration distance (> 3 $m \cdot s^{-2}$)	22	12	27	9	29	11	27	12
$\%HR_{mean}$ (%)	79.5	6.3	78.7	7.2	78.3	6.6	76.6	7.5
$\%HR_{max}$ (%)	93.2	4.8	91.2	5.8	90.6	6.1	88.9	6.5

Note: 11M = 11-a-side matches; SGL = large small-sided games; SGM = medium small-sided games; SGS = small small-sided games; %HRmean = percentage of mean heart rate; $\%HR_{max}$ = percentage of maximum heart rate.
a: Significantly different to SGL at $p < 0.05$, b: Significantly different to SGM at $p < 0.05$, c: Significantly different to SGS at $p < 0.05$, *$p < 0.01$.

Table 3 Technical performance during 11M and SGs.

	11M		SGL		SGM		SGS	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Number of tackles	3.5[c]	1.1	4.0	1.8	3.4[c]	1.3	5.7	2.1
Number of blocks	0.6	0.7	0.6	1.0	1.2	0.9	1.6	1.2
Number of touches	8.2[c*]	3.8	11.0[c]	6.3	12.5	4.4	18.8	7.3
Number of passes	19.8[c*]	6.7	24.4	6.8	25.2	4.7	31.5	7.2
Number of headers	1.5	1.0	0.7	0.6	0.8	0.9	1.0	0.6
Number of shots	0.9[bc*]	0.8	3.6	2.4	4.1	2.6	5.5	3.9
Number of dribbles	12.1	6.0	15.3	5.6	15.3	4.3	16.8	5.1
Ball involvement	38.7[c*]	12.8	48.6[c]	11.3	50.1	10.4	62.2	10.3

Note: 11M = 11-a-side matches; SGL = large small-sided games; SGM = medium small-sided games; SGS = small small-sided games.
b: Significantly different to SGM at $p < 0.05$, c: Significantly different to SGS at $p < 0.05$, *$p < 0.01$.

frequency and distance, and peak speed, and a greater acceleration frequency; and 3) a reduction in area per player of SGs in comparison with 11M provides similar or greater technical demands.

The outcomes from all 11M and SGs were eight wins, six losses and two draws for a team. The teams scored 108 and 84 goals, and which would show that the teams were likely to be formed evenly and possessed similar strengths. Moreover, the participants from the present study covered 116 $m \cdot min^{-1}$ during 11M and which is similar to the distance covered by elite soccer players from England (under-16) and Qatar (under-17) as their total match running distance was 107-109 $m \cdot min^{-1}$ (Buchheit et al., 2010; Goto et al., 2015). On the other hand, high speed running distance during 11M from the current study (9 $m \cdot min^{-1}$) seems to be shorter than that of elite soccer players with similar age (11-12 $m \cdot min^{-1}$) (Buchheit et al., 2010; Goto et al., 2015). However, this outcome was expected as the high speed running distance differentiate standard of players (Mohr et al., 2003).

The present result demonstrated that total distance covered during 11M and SGs are similar when area per player is similar. This result agrees with previous studies which compared the running distance during 11M and SGs with various number of players per team (Casamichana et al., 2012; Gabett and Mulvey, 2008). Moreover, the current study displayed a decline in total distance covered during SGs when pitch size was reduced. Similar outcomes have been reported by a previous study which suggested that reductions in area per player is associated with a decline in total running distance during SGs (Casamichana and Castellano, 2010).

In the current study, distances covered at high speeds during SGs declined with a reduction in pitch size and such findings have been demonstrated in a previous study which included SGs with three different pitch sizes (Casamichana and Castello, 2010). Furthermore, the current study showed that distances covered by high speed running during 11M was approximately 30% shorter than SGL, not significantly different to SGM and more than four times longer than SGS. However, a previous study which compared high speed running distance between 11M and SGs illustrated that the distance covered at high speeds (> 5.8 $m \cdot s^{-1}$) was more than twice during 11M compared to SGs in semi-professional soccer players when area per player of SGs (210 m^2) was around 70% of 11M (300 m^2) (Casamichana et al., 2012). This disagreement occurred possibly because the pitch size of SGs was not large enough for semi-professional soccer players in the previous study as the length and width of the pitch of the most SGs were < 50 m and < 35 m, respectively (Casamichana et al., 2012). Another potential rationale is that the current study only included central defenders, central midfielders and strikers whereas the previous study did not have such restrictions. Lateral defenders and lateral midfielders cover a greater distance at high speeds compared to other playing positions during a match (Bradley et al., 2009; Di Salvo et al., 2007) that not including lateral players in the current study may have created a gap with the previous findings (Casamichana et al., 2012).

Although area per player and total distance covered was similar between 11M and SGL, high speed running distance and frequency were greater during SGL compared to 11M. In SGL, there were only five

field players in a team opposed to ten field players in 11M that the players were possibly forced to execute high speed running more frequently to move away from defenders to receive the ball or chase opposition players when defending during SGL compared to 11M. Moreover, as mean distance of a single high speed running was similar between 11M (5.8 m) and SGL (6.4 m), overall high speed running distance was probably greater during SGL compared to 11M due to the greater high speed running frequency during SGL. The same trend was observed when high speed running distance and frequency were compared between 5-a-side and 3-a-side SGs with a similar area per player (Aguiar et al., 2013).

The current study measured acceleration frequency and distance covered whilst accelerating. This is a novel finding as an information regarding acceleration was not included in the previous studies which compared the physical demands of 11M and SGs (Casamichana et al., 2012; Gabett and Mulvey, 2008). The present result demonstrated that the trained young soccer players accelerated at 1-2 and 2-3 $m \cdot s^{-2}$ more frequently during SGS than 11M but the overall acceleration distances did not differ between the two. This is possibly because of the small pitch size employed in SGS. The pitch dimension of SGS was 39 x 25 m that it probably only allowed the players to accelerate for a shorter distance in each bout during SGS compared to 11M and such influence lead to a production of the higher number of accelerations during SGS. Moreover, the information regarding acceleration is important as it requires a high rate of force production compared to a constant speed running and substantially contribute to the physical demands of soccer (Osgnach et al., 2010).

In the present study, high speed running distance differed between 11M and SGs but HR responses ($\%HR_{mean}$ and $\%HR_{max}$) were not significantly different. Whereas, a previous study which examined HR responses during 6-a-side SGs (goalkeeper included) with different pitch sizes showed a decline in HR responses and running distances during SGs when the pitch size was reduced (Casamichana and Castello, 2010). This conflict may have occurred due to a different trend in technical performance between the studies. In the current study, a greater number of technical events were observed during SGs when the pitch size was reduced and this may have raised exercise intensity during SGs with smaller pitch sizes and probably increased $\%HR_{mean}$ and $\%HR_{max}$. On the other hand, the previous study reported that number of technical events occurred during SGs was similar regardless of the pitch size (Casamichana and Castello, 2010). Hence, given that high speed running distance was different between 11M and SGs, the increase in occurrence of technical events with the reduction in pitch size have probably raised exercise intensity during SGs with smaller pitch sizes that $\%HR_{mean}$ and $\%HR_{max}$ were similar between 11M and SGs in the current study. In addition, a number of acceleration was greater during SGS compared to SGL and this may also had raised the HR responses.

Moreover, peak speed was significantly slower during SGS compared to 11M, SGL and SGM. This is possibly explained by the differences in pitch sizes because shorter length and width of the pitch does not provide enough running distance for players to accelerate to high speed as reported previously (Casamichana and Castello, 2010).

During 11M, the players from the current study showed a similar number of tackles, passes, headers, shots and ball involvement compared to English Championship players and/or players from most successful teams in highest professional soccer league in Italy when the frequency was standardised into an hour (Rampinini et al., 2009; Russell et al., 2013). There were no differences in number of technical events occurred during 11M and SGs when the area per player was the same (SGL). This is an interesting finding as the result suggests that similar technical demands to 11M can be provided by SGs and an inclusion of frequent match specific activities in SGs makes the training stimulus more specific to the demands of sport (Rampinini et al., 2007). Moreover, the players attempted a significantly higher number of shots during SGM compared to 11M and the players performed a higher number of tackles, touches, passes and shots, and gained a higher number of ball involvement during SGS compared to 11M. Therefore, reductions in area per player of SGs lead to an increase in frequency of technical events during SGs as reported previously (Casamichana and Castellano, 2010). Hence, coaches are advised to employ SGs with the same area per player as 11M when they prefer to provide a similar technical stimulus as 11M during a training session. On the other hand, coaches should reduce the pitch size of SGs if their purpose is to provide a greater amount of technical events than 11M to the players during a training session. In addition, some technical

events (e.g., headers) were not performed frequently during SGs that coaches may need to include different drills in training sessions to provide a chance for the players to improve or maintain certain skills.

The current study showed that similar or greater frequency of several technical events can be provided during SGs compared to 11M. However, some technical events or situations occur during 11M would never appear during SGs. For example, the distance from a corner to a centre of goal during SGs will not be greater than 25 m in the current study. Whereas, the distance between a corner and a centre of goal was 34 m during 11M in the current study. Hence, the same corner kick would never happen during SGs and 11M. Moreover, there are 11 oppositions during 11M and six oppositions during 6-a-side SGs that it is possibly much easier to gain a chance to be surrounded by a few defenders and deal with a difficult situation to maintain the possession of the ball during 11M compared to SGs. Therefore, it is important to note that it is probably difficult to create certain technical events or situations during SGs which can appear repetitively during 11M.

5. Conclusion

The current study investigated the differences in physical and technical performances during 11M and 6-a-side SGs with various pitch sizes in trained young soccer players. The findings demonstrated that similar physical and technical demands to 11M can be provided by SGs in trained young soccer players as long as area per player is similar. On the other hand, a reduction in area per player of SGs in comparison with 11M results in less total running distance and high speed running distance, and a greater acceleration frequency. Furthermore, a reduction in area per player of SGs in comparison with 11M results in a greater frequency of tackles, touches, passes, shots and ball involvement. Therefore, coaches should carefully choose a pitch size of SGs depending on the physical and technical stimulus they are aiming to deliver to the players during training sessions.

6. Practical applications

- Physical and technical demands of 6-a-side SGs can be similar to 11M as long as area per player is similar.
- Reducing area per player of 6-a-side SGs in comparison with 11M would lead to a decrease in total running distance and high speed running distance, and a greater acceleration frequency.
- A reduction in area per player of 6-a-side SGs in comparison with 11M would provide a greater number of technical events to the players.

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