

Research article

Effects of small-sided games on physical conditioning and performance in young soccer players

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Abstract

The purpose of this study was to examine, first, the movement actions performed during two different small-sided games and, second, their effects on a series of field endurance and technical tests. Thirty-four young soccer players (age: 13 ± 0.9 yrs; body mass: 62.3 ± 15.1 kg; height: 1.65 ± 0.06 m) participated in the study. Small-sided games included three-a-side (3 versus 3 players) and six-a-side (6 versus 6 players) games consisting of 10 bouts of 4 min duration with 3 min active recovery between bouts. Soccer player performance was evaluated using five field tests: a) 30m sprint, b) throw-in for distance, c) Illinois Agility Test, d) dribbling the ball and e) horizontal jump before, in the middle and after the implementation of both game situations. Heart rate was monitored during the entire testing session. Each game was also filmed to measure soccer movements within the game. The ANOVA analysis indicated that the three-a-side games displayed significantly higher heart rate values compared with the six-a-side games ($p < 0.05$). The number of short passes, kicks, tackles, dribbles and scoring goals were significantly higher during the three-a-side compared with the six-a-side game condition ($p < 0.05$) while players performed more long passes and headed the ball more often during the six-a-side ($p < 0.05$). After the three-a-side games, there was a significant decline in sprint and agility performance ($p < 0.05$), while after both game conditions significant alterations in the throw-in and the horizontal jump performance were observed ($p < 0.05$). The results of the present study indicated that three-a-side games provide higher stimulus for physical conditioning and technical improvement than six-a-side games and their use for training young soccer players is recommended.

Key words: Soccer, small-sided games, field tests, technical actions, intermittent exercise.

Introduction

Soccer match analysis shows that players are in possession of the ball for only 2% of the game duration (Dufour, 1993). In the remaining part, players run without the ball, based on the team tactical strategy. The success of team strategy depends on the players' ability to co-operate in a certain area of the pitch with their team-mates. Therefore, soccer specific training exercises usually include game conditions played with less number of players in smaller field dimensions. These particular exercises are known as small-sided games (Rampinini et al., 2007).

Small-sided games are often used from adults as part of their regular training programs in various forms, depending on the aim and the philosophy of the coach.

Rampinini et al. (2007) underlined the importance of using different small-sided games by changing each time the number of participants. From a practical point of view, games with a larger number of players seem to be used for tactical and technical improvement, whereas games with a smaller number of players are mainly used for endurance and physical conditioning improvement. In order to support this hypothesis, an examination of the instant effects of games with a different number of players on endurance performance and on technical characteristics is needed.

Small-sided games are very popular not only in adult soccer players but also in young players and their use begins from an early age. Due to the smaller pitch and the less number of participants during small-sided games, each player comes into contact with the ball and deals with common game situations more often (Capranica et al., 2001). These situations require good technical skills such as passing, dribbling and kicking, as well as tactical skills such as running without the ball, unmarking and cooperation with other players.

A variety of field tests and technical skills is commonly used to examine the endurance capacity and the technical ability of a soccer player (Bangsbo and Lindquist, 1992; Rosch et al., 2000; Scott and Doherty, 2004; Vesconi and McGuigan, 2007; Kelly and Drust, 2008). However, endurance and technique performance impairments are evident as the game progresses. This underlines the important role of fatigue for game performance (Mohr et al., 2003; Kelly and Drust, 2008).

Talent identification aims to increase the probability of selecting a future elite player at an early age (Franks et al., 2002). This process often involves the examination of performance of the young player in a series of field tests as well as his/her behavior during game situations (Williams and Franks, 1998). Small-sided games may be useful tools for the identification of talented young players. Although the effects of small-sided games on aerobic fitness and physical match performance in adult players have been examined (Impellizzeri et al., 2006), similar data for younger players have not been reported. Only one study (Platt et al. 2001) examined the type and the frequency of various skills during small-sided games in young players. It was reported that when young players participated in three-a-side games they had more opportunities to perform skills such as dribbling, passing and shooting compared with participation in five-a-side games. This suggests that different small-sided game conditions may show different responses and, therefore,

they may be used for a different purpose as part of soccer training. This is important for youth soccer, where the aim of training is not always to enhance team strategy but also to allow young players to enhance their technical skills and to develop team cohesion. The aim of the present study was to examine, first, the movement actions performed during two different small-sided games and, second, their effect on a series of field endurance and technical tests.

Methods

Participants

Thirty-four amateur young soccer players (age: 13 ± 0.9 yrs; body mass: 62.3 ± 15.1 kg; height: 1.65 ± 0.06 m) participated in the study. A minimum of five years of training experience, a training status of at least two training sessions plus a game per week and no history of injury in the last six months were the main criteria for participating in the study. Subject and parental informed written consent was received and the University Ethics Committee approved the protocol.

Study design

The subjects were randomly assigned to three groups. Group 1 ($n = 12$) performed only the three-a-side game situation. Group 2 ($n = 12$) performed only the six-a-side game situation while Group 3 ($n = 10$) served as controls. Testing of each group was performed on separate occasions. The number of technical actions during the game was examined using video recordings. Field tests were performed in a random order before (pre) the games, in the middle (after the 5th bout) and after (post) the games. The control group performed only the field tests without a game intervention.

Three-a-side and six-a-side games

Two days before the main measurements, the participants were asked to refrain from any vigorous exercise. The protocols were performed during the mid-season, in an outdoor field with natural grass and at the same time of the day in order to avoid circadian effects. The size of the pitch was 15 m wide and 25 m in length for the three-a-side game situation and 30 m wide and 40 m in length for the six-a-side game situation (Rampinini et al., 2007).

Each game had an overall duration of 70 min and it consisted of 10 bouts of 4 min duration with 3 min active recovery between exercise bouts. The duration was selected in order to simulate a U-14 soccer game. The recovery between the 5th and the 6th bout was 15 min. Heart rate (HR) values were recorded every 15-sec during the entire testing session using sort-range radio telemetry (Polar Sport tester, Polar Electro Oy, Kempele, Finland). The mean heart rate collected throughout the ten bouts of small-sided games was calculated to provide an indication of the intensity of the small-sided games.

Two-weeks prior to testing, the maximum heart rate (HR_{max}) of each player was determined using the Yo-Yo endurance test (Rampinini et al., 2007). The Yo-Yo test consisted of 20 m shuttle runs performed at continuously increased speeds until exhaustion. HR_{max} values were used as reference values for the quantification of HR

values observed during each small-sided game.

The three-a-side and six-a-side games were conducted with two goalkeepers and free touches. A necessary requirement for scoring goals was that all players should be in the opponent's half. Coach encouragement using standardized instructions was allowed (Rampinini et al., 2007). Water ingestion was allowed after the 5th and the 10th bout of the game protocol. During the entire testing session air temperature ranged from 23 to 26 °C and humidity from 55 to 65%.

Video analysis

Each game was also filmed using a camcorder (Sony Handycam DCR-SR35E, SONY Corporation, China) to evaluate the technical actions taking place during each game condition. Technical actions were categorized into six discrete categories: short passing (distance less than 10 m), long passing (distance more than 10 m), dribbling, shooting, heading and tackling (Kelly and Drust, 2008). To determine pass length, external markers were located in various field positions and their location relative to the camera was recorded. The pass length was then obtained from the video footages, by scaling the distance of the pass relative to known distances (defined by the external markers). The number of goals scored during each game was also calculated.

Field tests

The field tests performed in the present study are frequently applied to evaluate players' physical ability (Bangsbo and Lindquist, 1992; McGregor et al., 1999; Rosch et al., 2000; Scott and Doherty, 2004; Vesconi and McGuigan, 2007). After a brief warm-up, the participants performed five field tests: 1) horizontal jump test, 2) dribbling test, 3) throw-in test, 4) agility test and 5) sprinting test. The tests were performed in random order for each subject on each testing occasion. All the tests were performed outdoors, on a natural grass soccer pitch with players wearing soccer boots. All the players were accustomed to the field tests, as they were part of their regular training programme. Each player had several familiarization efforts and then performed three maximum trials. The best performance on each field test was used for further analysis.

1. Horizontal jump test: Each participant was instructed to perform a maximum horizontal jump (Scott and Doherty, 2004). The participant started from a standing position placing both feet just behind the starting line. After several preparatory standing movements, a horizontal jump with free hand contribution was performed. The distance from the starting line to the heel of the rear foot (to the nearest 0.5 cm) was recorded.

2. Dribbling test: The speed dribbling test was used to assess the ability to dribble under time pressure (McGregor et al., 1999). Six cones were placed in a line with 3 m distance between them. The participant was instructed to dribble a match ball of standard size and standard inflation (Mitre Ultimatch, size 4, FIFA approved), forward around the cones in slalom and then return at the initial position. The objective was to complete the test as fast as possible without knocking down the cones. If a cone was knocked down, the trial was

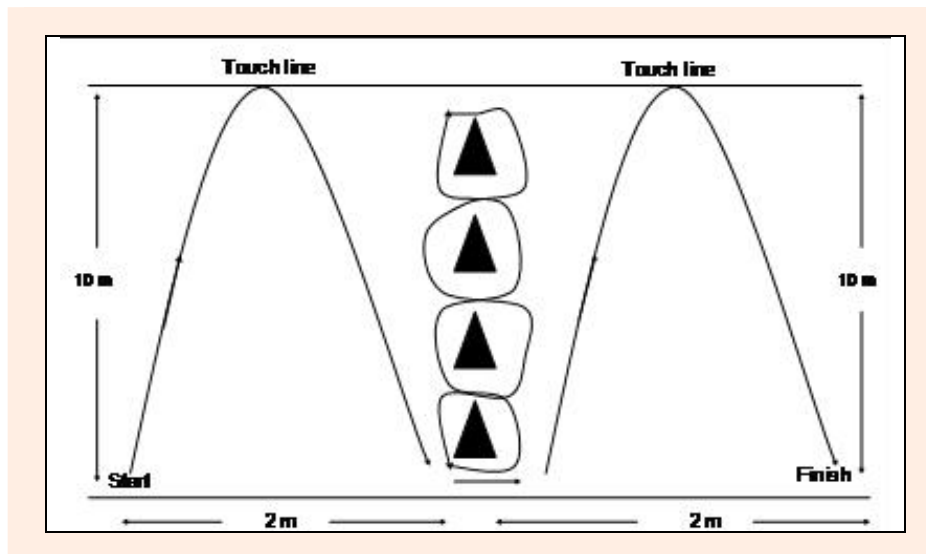


Figure 1. A schematic presentation of the Illinois Agility Test.

cancelled. The time from the start of the test until the player returned to the initial position was recorded by two experienced coaches using a stopwatch. The mean value from the two coaches was used for further analysis.

3. Agility test: The Illinois test was used to evaluate agility (Vesconi and McGuigan, 2007). A schematic presentation of the test is shown in Figure 1. Two lines were drawn on the pitch at a distance of 10 m from each other. The first line served as the starting and end-point line, while the other served as the touch line. The player started off by lying down with the hands next to the shoulders (start). After a verbal signal, the players got up and sprint until the touch line (point A). They then sprint back to the starting line (point B) and immediately performed a sprint around the cones. After sprinting around the cones they sprint back to the touch line (point C) and finally returned to the finish line (finish). The subjects were instructed to run as fast as possible without falling and knocking down the cones. If a cone was knocked down or the participant did not follow the prescribed path, the trial was cancelled. Two stopwatches were activated at the verbal signal and were stopped when the participant crossed the finish line. The average time of the two stopwatches was used for further analysis.

4. Soccer throw-in test: The participant started from a standing position placing the feet just behind the starting line holding a ball in the hands. The subjects throw the ball as far as possible without jumping or moving their feet (Rosch et al., 2000). If a player jumped, moved his feet or threw the ball with an inappropriate way the trial was cancelled. The throwing distance was further analysed.

5. Sprint test: The participant performed three maximum 30 m sprints. Sprint times were recorded using infrared photoelectric cells interfaced to a timing system (Saint Wien Digital Timer Press H5K, Lu-Chou City, Taipei Hsien, Taiwan) with a time resolution of 0.01 s and a measurement error of ± 0.01 s.

Reliability

Two weeks before the final measurements a pilot study

was conducted in order to examine the reliability of the field tests. The intraclass correlation coefficient was high (0.96 for the horizontal jump test, 0.88 for the dribbling test, 0.94 for the agility test, 0.85 for the throw-in test and 0.90 for the sprint test). The coefficient of variance was 6.11% for the sprint test, 4.15% for the agility test, 4.61% for the dribbling test, 9.10% for the horizontal jump test and 15.65% for the throw-in test.

The reliability of the technical action measurements made using the recorded video tapes of each small – sided game was also examined (Kelly and Drust, 2008). Particularly, each recorded game was re-analysed by the same investigator. Subsequently, the number of exact agreements between the test (first video analysis) and re-test (second video analysis) were used to compute the kappa coefficient (Kelly and Drust, 2008). The results showed a kappa coefficient of 0.85 which indicates a high level of agreement between the two measurements.

Statistical analysis

Differences between the three-a-side and the six-a-side games in passing, dribbling, heading, shooting, tackling and goal scoring values were examined using independent two-tailed Student's t-tests.

A two-way analysis of variance (ANOVA) with repeated measures was applied to examine the differences in HR values between the ten bouts of each game protocol.

A two-way mixed-model ANOVA design (Time x Group) was applied to examine the differences in each field test score between the three groups of subjects (three-a-side group, six-a-side group, controls) performed before, in the middle and after each small sided game. When required, comparisons of group means were performed using a Tukey's post hoc test. The level of statistical significance was set at $p < 0.05$.

Results

Heart rate (HR) characteristics

Heart rate (HR) values during the ten bouts of both

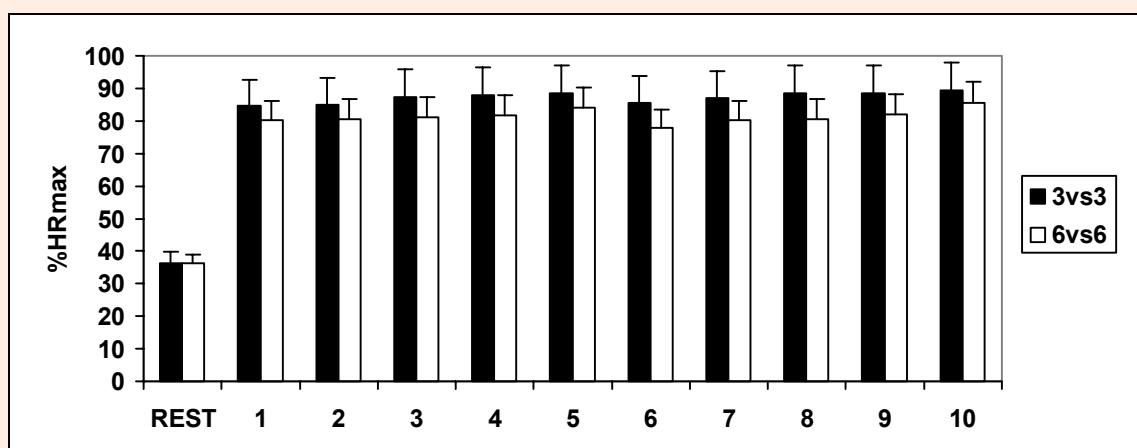


Figure 2. Mean (\pm SD) percentage of maximum heart rate (HR_{max}) during the fatigue protocol for three-a-side and six-a-side game situation.

fatigue protocols are presented in Figure 2. The ANOVA results indicated a non-significant (Time \times Group) interaction effect. In contrast, a main effect for “Group” was observed ($p < 0.05$). *Post hoc* analysis indicated that the group who played three-a-side games displayed higher HR values compared with those who played six-a-side games ($87.6 \pm 4.77\%$ of HR_{max} versus $82.8\% \pm 3.22\%$ of HR_{max} , respectively) ($p < 0.05$).

Field tests

The mean values of all tests are presented in Table 1. The ANOVA results indicated a significant interaction effect (Time \times Group) on agility performance (Table 1, $p < 0.05$). *Post hoc* analysis indicated significant differences between the groups in the three time sessions (< 0.05). Compared to pre-game test scores, agility decreased significantly after the three-a-side and the six-a-side game groups, but remain unaltered for the control group ($p < 0.05$).

The ANOVA results indicated a non-significant interaction effect (Time \times Group) on jumping performance (Table 1, $p > 0.05$). However, a main effect for “Time” was observed ($p < 0.05$). *Post hoc* analysis showed that for both groups post exercise values were significantly lower than the pre-exercise values ($p < 0.05$).

There was a non-significant interaction effect on throw-in performance (Table 1, $p > 0.05$). However, a main effect for “Time” was observed ($p < 0.05$). *Post hoc* analysis indicated that post-game scores were significantly lower compared with pre-exercise and mid-exercise values ($p < 0.05$).

The ANOVA also indicated a significant interaction effect (Time \times Group) on sprint performance (Table

1, $p < 0.05$). *Post hoc* analysis indicated significant differences between the groups in the three time sessions ($p < 0.05$). Particularly, compared to pre-game scores, sprint scores increased significantly in the middle and after the implementation of the three-a-side and the six-a-side game, but remain unaltered for the control group ($p < 0.05$).

There was a non significant interaction or main time or group effect on dribbling performance (Table 1, $p > 0.05$).

Technique actions

The number of short passes, long passes, dribbles, headers, tackles, kicks and goals scores for each game condition are presented in Figure 3. The t-tests indicated that the number of short passes, kicks, tackles, dribbles and scoring goals was significantly higher during the three-a-side game compared with those observed during the six-a-side game ($p < 0.05$). The opposite was observed for the number of long passes and headers ($p < 0.05$).

Discussion

The main findings of this study were that both small-sided games resulted in a significant decline in throw-in and horizontal jump performance. Sprint and agility performance were altered only after the three-a-side games. Moreover, technique actions and scoring goals were game dependent.

Three-a-side versus six-a-side HR responses

The exercise protocols used in the present study displayed similar HR responses to those previously reported for

Table 1. Mean (\pm SD) field test scores between the three groups (three-a-side, six-a-side, controls) through the time (pre, middle, post).

	3-a-side			6-a-side			Controls		
	Pre	Middle	Post	Pre	Middle	Post	Pre	Middle	Post
Sprint (sec)	4.98 (.24)	5.17 (.28)*	5.40 (.33)*	5.13 (.45)	5.30 (.48)*	5.45 (.43)*	5.09 (.35)	5.12 (.43)	5.15 (.46)
Agility (sec)	17.64 (.90)	17.81 (.95)	18.21 (1.15)*	17.92 (1.53)	18.00 (1.34)	18.19 (1.38)*	18.06 (.90)	18.13 (.86)	18.12 (.81)
Dribbling (sec)	13.35 (.65)	13.44 (.89)	13.82 (.94)	13.33 (.94)	13.20 (1.37)	13.47 (1.21)	13.24 (.57)	13.21 (.50)	13.24 (.50)
Throw-in (m)	12.0 (2.2)	11.4 (2.2)*	10.6 (2.2)*	12.1 (3.2)	12.1 (2.9)	11.9 (3.0)*	11.3 (1.4)	11.4 (1.5)	11.3 (1.5)
Jump (m)	1.92 (.13)	1.89 (.15)	1.86 (.10)*	1.85 (.26)	1.85 (.25)	1.82 (.27)*	1.78 (.06)	1.77 (.07)	1.78 (.07)

* Significantly different compared with pre values ($p < 0.05$).



Figure 3. Mean (\pm SD) number of technical actions and scoring goals during the three-a-side and the six-a-side game situation (error bars indicate SD). * significantly different, $p < 0.05$.

soccer players during small-sided games (Rampinini et al., 2007) for pre-pubescent players during eleven-a-side games (Capranica et al. 2001). It has been suggested that HR values exceeding $170 \text{ beats}\cdot\text{min}^{-1}$ represent high intensity work activities (Capranica et al., 2001). If this is the case, then our HR results suggest that the young players participating in both small-sided games worked at high levels of intensity.

The three-a-side game displayed higher exercise intensity compared with the six-a-side game situation (Figure 2) which is in agreement with Rampinini et al. (2007). Capranica et al. (2001) compared the physiological responses of eleven-a-side versus seven-a-side small games and they suggested that the less number of players, the more ball contacts from all players. This appears to support the present results as players touched and dribbled the ball more often during the three-a-side game compared with the six-a-side game (Figure 3). Reilly and Ball (1984) reported an increase in rate of perceived exertion and blood lactate when dribbling a ball for several minutes, probably due to the extra muscular activity required to control the ball and to propel it forward. Although continuous dribbling applied by Reilly and Ball (1984) is not the same as the total number of dribbles and ball contacts recorded in this study, the higher number of dribbles and ball contacts could have partly contributed to a higher exercise intensity observed in three-a-side games compared with six-a-side ones. In addition, since three-a-side games involve less number of players, it may also be hypothesized that players have to work harder off the ball to create space which might result in a greater physiological impact than that observed during six-a-side games.

Three-a-side versus six-a-side game differences in movement actions

The results of this study indicated that more long passes were performed during the six-a-side games as opposed to the three-a-side condition (Figure 3). Similar results were reported when comparing three-a-side versus five-a-side soccer games in players aged under 12 (Platt et al., 2001). This could be attributed to the greater pitch dimensions during the six-a-side game which allows players to perform longer passes. In turn, longer passes often require from the players to receive and pass the ball to each other by performing a header. This explains the higher number

of headers observed during the six-a-side game compared with three-a-side ones (Figure 3). In contrast, a higher number of short passes was found during the three-a-side games (Figure 3). This suggests that when the pitch dimension is small the players cooperate with their teammates via short and quick passes, rather than headers.

The players performed more shots during the three-a-side compared with the six-a-side game condition (Figure 3). This increases the opportunity for scoring a goal and it can explain the higher number of goals scored during the three-a-side games (Figure 3). Kelly and Drust (2008) found in adults that the smaller the pitch dimensions, the more kicks are performed by adult players. Similarly, Platt et al. (2001) observed more goal attempts when small-sided games were performed with less number of players.

The number of dribbles and tackles performed during the three-a-side games was higher compared to those performed during the six-a-side games (Figure 3). Similar results were reported by Platt et al. (2001) comparing three-a-side with five-a-side games. The smaller pitch results in increased pressure from the opponents and this situation requires from the players to dribble the ball more often in order to avoid the opponent's pressure (Kelly and Drust, 2008).

Three-a-side versus six-a-side game effects on field test scores

The present study showed that jumping scores declined similarly after both small-sided game conditions (Table 1). Horizontal jumping skill is characterised by a short and a quick production of force and power, especially by the hip extensors. The reduction of jump scores following our protocols agrees with previous findings which showed reduced performance and neuromuscular activity after a soccer game on multi-articular movements such as the horizontal jump (Mohr et al., 2004).

The throw-in test scores also declined in the middle and after both small-sided game conditions (Table 1). Better throw-in performance is achieved by increasing release speed and optimum release angle (Linthorne and Everett, 2006). This skill requires explosiveness rather than endurance. Therefore, the exact reason for our observation is not clear. It could be hypothesised that the high level of intensity observed during both game conditions

may have had a negative effect on throw-in performance.

Sprint performance showed a higher decline after the three-a-side compared with the six-a-side game (Table 1). These results are in agreement with previous studies examining 11-a-side soccer games (Mohr et al., 2004; Krstrup et al., 2006). Sprint running involves stretch-shortening cycle muscle function of both lower and upper body musculature (Dintiman, 2003) with increased metabolic demands (Delecluse, 1997). Moreover, a high correlation between muscular power with sprinting performance was reported (Wisloff et al., 1998). Although the above findings refer to adult players, they suggest that higher endurance levels are needed in order to maintain performance. This might explain the reduction in sprinting performance after both games and particularly after the three-a-side games were increased level of endurance is needed.

Agility is a complex ability and it depends on several factors, such as muscle strength, speed, balance and skill (Cable, 1998). The results of the present study showed a significant decline in agility performance for the three-a-side games compared to six-a-side and controls (Table 1). Previous studies in adults suggested significant alterations in muscle strength (Thorlund et al., 2009) and balance (Nardone et al., 1997) after fatigue. These observations coupled with reductions in sprint performance and high-intensity effort observed in this study might be responsible for the reduction in agility scores (Table 1).

The results of the present study indicated non-significant differences in the dribbling test between the two small-sided games. Performance in the dribbling test requires more technical skill rather than endurance capacity. The above findings are in agreement to previous studies in adults that reported non-significant alterations in the main soccer kick technique after fatigue (Kellis et al., 2006).

Implications for soccer training

Bangsbo (1994) suggested that training programs for young soccer players should aim to improve technical skills rather than physical conditioning. The results of the present study indicated that three-a-side games provide better stimulus for physical conditioning than six-a-side ones. Moreover, they provide better stimulus for technical improvement as more technical actions were observed. Similarly, Platt et al. (2001) support the promotion of the three-a-side game for young players. This does not indicate that the use of six-a-side games as part of soccer specific training is unnecessary. In terms of number of players and pitch size, the six-a-side game is closer to the real game conditions than the three-a-side game. Our suggestion is that the three-a-side games might be better for developing technique and the six-a-side for tactical performance. Further research is needed to examine the above suggestion.

A limitation of this study was that time was measured with the use of stopwatches. To account for this, time was measured by experienced investigators, which is reflected on the high test-retest reliability coefficients for all tests applied in the present study. Another limitation of this study is that we assessed sprinting capacity using a 30 m sprint test. Although this provides a general index of

sprinting capacity, it does not simulate actual game sprinting performance, as players often perform quick and short accelerative runs rather than maximum 30 m sprints. Therefore, sprinting ability over shorter distances could be more important. Consequently, although our results suggest that sprinting capacity was altered following the two game situations, a future study including a 10 m sprint test might provide additional useful information about reaction and acceleration sprinting capacity adaptations to various soccer game conditions.

Conclusion

The present study indicated that soccer players display high intensity levels when participating in small-sided games. As a result, a reduction in field test scores was observed. Three-a-side games affected sprint and agility performance. In contrast, six-a-side games had less effect on physical performance in field tests. The above suggest that the use of three-a-side games for improving fitness and technique in young soccer players may be more appropriate.

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Key points

- Three-a-side games display higher HR compared with six-a-side games.
- In the three-a-side games players performed more short passes, kicks, dribbles, tackles and scored more goals compared with the six-a-side games.
- Impairment in endurance and field test performance was observed mainly after three-a-side games.
- The use of the three-a-side games to develop physical fitness and technique in young soccer players is recommended.

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