Manipulation of exercise to rest ratio within set duration on physical and technical outcomes during small-sided games in elite youth soccer players.

Abstract

Training practises for elite soccer players should take into account specific technical, tactical and physical components. As a consequence of these demands small-sided games (SSGs) have become a popular conditioning tool that replicate the demands encountered during match play. The aim of this investigation was to examine how the manipulation of exercise to rest ratio, within the same overall duration, affected both physical and technical outcomes during SSGs in elite youth soccer. Twelve elite youth soccer players participated in three variations of eight minute 6v6 SSGs. The three variations included eight minutes continuous, 2x4 minutes and 4x2 minutes. Players perceived the continuous 8 minute block as the hardest (4.5±1.5 AU), followed by the 2x4 minutes (3.9±1.4 AU) and the 4x2 minutes (3.3±1.4 AU), although no difference in mean HR or physical measures via GPS analysis between SSGs was evident. From the technical perspective, only goals scored reached significance, with post-hoc analysis identifying the number of goals scored were significantly higher during the 4x2 minute and 2x4 minute SSGs compared to 8 minute continuous block. These results show that subjective ratings of exertion differed between conditions, but only minor technical manipulations were observed by adjusting work to rest ratios, with no significant effect on physical performance.

Key words: Soccer training; SSG; exercise:rest ratio; GPS; Technical analysis.

1.0 Introduction

Soccer is a physically demanding sport, where the aerobic and anaerobic systems are highly taxed (Mohr et al., 2003). Players will typically cover 10-13 km during a game, performing 150-250 intense activities such as accelerations/decelerations, changes of direction, all of which are interspersed with short recovery periods (Bangsbo et al., 2006), in addition to technical actions that include approximately 15 tackles, 10 headings, and 50 involvements with the ball (Stølen et al., 2005). Therefore, physical conditioning in elite soccer is of upmost importance for coaches, practitioners and researchers alike.

In recent years, much attention has focused on the use of small-sided games (SSGs) as a conditioning tool in elite soccer due to the similar demands to match play (Aguiar et al., 2012). Small sided games offer the opportunity to develop technical-tactical elements concurrently with specific fitness capacities as endurance (aerobic and anaerobic), strength and agility (Hill-Haas et al., 2011). Small sided games are performed on smaller pitch areas, often under modified rules and with fewer players than traditional match-games (Hill-Haas et al., 2011). Impellizzeri et al. (2006) found SSGs to significantly improve aerobic fitness to the same degree as a generic fitness session, concluding that both were equally as effective in a sub elite youth population. These findings have been confirmed within an elite population (Hill-Hass et al., 2009a). Moreover, the authors also found players to perceive SSGs as less intense and physically easier. The use of perceived ratings of exertion has been commonly used within football and team sports, and is universally accepted as a valid measure (Robertson et al., 1998). Further, Roberson et al. (1998) stated that rating of perceived exertion (RPE) is an easily applied measure for assessing functional aerobic power and prescribing intensity of exercise for use in a variety of sport. Recently, during a season-long period of field-based soccer training, Kelly et al. (2016) found a high correlation between changes in RPE and heart rates within a sample of elite soccer players irrespective of playing position. Therefore, with application to training being vitally important, SSGs offer an interesting alternative to generic fitness sessions.

Over recent years, researchers have manipulated numerous organisational details of SSGs to investigate how this affects both physical and technical responses. SSGs rule manipulations can change the physiological load, therefore SSGs characteristics should be adapted to suit the training aim. For instance, increasing pitch size so that the area per player is greater has been shown to increase the heart rate (HR), lactate response and perceived effort (Rampinini et al., 2007; Hill-Haas et al., 2009b). Furthermore decreasing the number of players appears to increase the HR response (Hill-Haas et al, 2009b), as well as increasing the number of technical actions due to less players being involved (Jones and Drust, 2007). Manipulating rules by removing goalkeepers and making it a possession based game increases total distance but leads to decreases in high speed running as well as maximal velocities (Gaudino et al., 2014). Dellal et al. (2008) suggested the increase in intensity observed with the inclusion of goalkeepers could be due to increased motivation as a result of the game becoming more realistic. Including training designs that are not synonymous with the training aims, which may for example use incorrect recovery times, protocol durations, pitch size dimensions and number of players could impair SSGs outcomes. Therefore to design relevant soccer protocols, it is paramount that the above parameters and rule manipulations are accounted for to ensure the correct technical outcomes and its association to external and internal load emerge (Beato et al., 2014).

It is clear that SSGs have received a great deal of focus within the literature, although limited research has been conducted within elite youth soccer. Therefore, the rationale for the current investigation is to provide clarity on the impact of manipulating bout number and utilising an ecological duration within a session. The aim was to investigate the effect of manipulating the exercise to rest ratio within an equal session duration, with consistent player number and pitch dimension, on both physical and technical outcomes. The hypothesis states that decreasing bout duration, and therefore increasing set number will increase exercise intensity and lead to more high intensity exercise, potentially due to the rest periods providing an opportunity to assist in the removal of metabolic waste and resynthesis of phosphocreatine, as well as increasing technical proficiency due to the increased rest periods.

2.0 Method

2.1 Participants

Twelve elite youth soccer players took park in the investigation (Age 15.8±0.6 years, Height 176.4±9.6 cm, Weight: 67.1± 9.9 kg). The players comprised the U16 squad of an elite category one soccer academy in England (Chelsea FC). They all followed the same physical program of four on pitch training sessions per week, and one competitive match. All players and parents gave their informed, written consent after they were informed of the experimental procedures, the associated risks and their right to withdraw. The academy manager gave informed approval for the investigation to include their players. The investigation was approved by the Liverpool John Moores Ethics Committee.

2.2 Procedures

The players participated in 6v6 SSGs on a 50x32 m area (length x width), with full sized goals utilised. The games took place on an artificial surface, in an indoor facility (inflated dome). Teams were selected by the coach in an attempt to pick appropriately and were comprised of five outfield players and one goalkeeper. The teams were set up in a formation consisting of two defenders, two midfielders and an attacker. However they were given freedom to interchange freely within the game. Players were informed of the rules prior to the game, play restarted from the goalkeeper and the offside rule did not apply. The games took place without coach encouragement, although the scores were recorded by the coaching staff and the players were aware. All of the aforementioned was kept consistent throughout testing

Upon arriving players were fitted with Polar T31 HR monitors and Global Position System (GPS) units. Players used gel on the HR straps to ensure optimal data collection. Prior to play all players took part in a standardised fifteen minutes warm up. They then participated in two variations of the eight minutes games, separated by two minutes of rest. Players were asked to provide their perceived exertion upon cessation of each respective game. The three variations were as follows: eight minutes continuous, two blocks of four minutes separated by one minute rest, and four blocks of two minutes separated by 45-60 seconds rest. The order in which these games took place was picked at random (8 min followed by 2x4min; 4x2min followed by 8min; 4x2min followed by 2x4min). The timings were set to an 8 min SSG as this reflects what typically would occur within the applied setting.

Familiarisation sessions were not deemed necessary as this game format was often used within team training, and the players were accustomed to wearing HR monitors and GPS units within their day-to-day training. All players also had a significant amount of experience using Fosters adaptation of the Cr10 RPE scale (Foster et al., 1995).

The three testing blocks took place on a Tuesday afternoon at the same time in December, January and February. Players were continually training at the club during this three month period, apart from a seven day break during the Christmas period, although players were prescribed physical work to maintain physical conditioning during this time. Buchheit et al. (2014) found that GPS outputs from the same file can vary significantly between software updates from the same provider, especially information on accelerations and decelerations. Therefore no software updates took place during this time.

2.3 Measurements

2.3.1 GPS

Activity was monitored using a GPS, sampling at 15 Hz (HPU, GPSports, Canberra, Australlia). Players wore tight fitted chest straps in order to wear the GPS units, meaning the units were positioned on the upper back of each participant. Units were turned on ten minutes prior to arrival to ensure optimal functioning. Speed zones were categorised into low-speed running (0-6km.h^{-1}) moderate-speed running (6 km.h^{-1}-17 km.h^{-1}) and high-speed running (>17 km.h^{-1}). High-speed runs were classified as any run that reached a velocity greater than 17 km.h^{-1}. Accelerations were classified as a movement greater than 2m/s/s and decelerations as: a movement less than -2m/s/s. Satellite visibility was a consideration when deciding to undertake the testing in the dome, however signal strength was tested by the club, and was unaffected by this inflated structure.

2.3.2 HR

In order to calculate internal load, HR was measured using Polar T31 belts (Polar Electro Oy, Kempele, Finland) and integrated within the GPS software (Team AMS, GPSports). Maximal HR was determined via the Yo-Yo intermittent recovery test Level 2 completed previously by the club. However, if a player hit a higher peak HR during training or matches this was taken as their maximum HR.

2.3.3 RPE

Subjective measures of exertion were calculated on the Cr10 RPE scale (Foster et al., 1995) and used along with HR to assess internal load, providing both psychological and physiological load (Impellizzeri et al, 2006). Consistency in timings of RPE collection is of upmost importance, so the process remained the same every time (Foster et al 2001). Players were asked individually to provide an RPE score in attempt to prevent influence of interaction with other players scores, and this occurred within the rest period between games and after the final game.

2.3.4 Technical analysis

SSGs were filmed using a digital video recorder (Sony XDcam pmw100) positioned on an endzone stand. The following technical actions were counted retrospectively using sports code software; passes, successful passes, individual possessions (every time a player was in controlled possession, held for greater than one second), regains (change of possession, team must regain possession for greater than one second), shots and shots on target. Two people conducted this analysis separately in order to account for human error.

2.4 Analysis

Shapiro-Wilk test was performed for the evaluation of normality (assumption) of statistical distribution. Technical actions were normalized with Box–Cox power transformation and then analysed by statistical software (Osborne, 2010). A one-way ANOVA was conducted among the three distinct conditions (8 min, 2x4 min and 4x2 min). A Bonferoni post-hoc test was conducted in order to determine between which conditions the significance existed. Statistical analyses were performed using SPSS version 12 for Windows 7 (SPSS, Chicago, IL, USA). Data is expressed as mean ± standard deviations. Statistical significance was set at $p<0.05$.

3.0 Results

RPE varied significantly between conditions ($p<0.05$), with players perceiving the eight minutes continuous block as the hardest (4.5±1.5 AU), followed by the 2x4 minute (3.9±1.4

AU) and the 4x2minute (3.3±1.4 AU). Despite a difference in perceived intensity, HR response showed very little variation. Mean HR, $\%HR_{max}$ and amount of time spent above 85% maximum HR showed no variation between conditions, so despite perceiving the continuous block as harder, the internal cost was no different (Table 1).

Significantly more goals ($p<0.05$) were scored in both the 4x2minute game (8±1), and the 2x4 (7±1) minute game, as opposed to the 8 minutes continuous game (5±1), seemingly due to the greater number of shots taken 13±2 (8 min) vs. 17±2 (2x4 min) vs. 23±4 (4x2 min) (Table 2). Although not to a level of significance ($p>0.05$) number of regains appeared to be greater as the bout duration decreased (4x2 min > 2x4 min > 8 min), which unsurprisingly coincided with the same pattern being seen with number of unsuccessful passes. There was no significant difference in total number of passes between groups, as well as individual possessions.

Despite the result being below significance there is a tendency for more low intensity running as the continuous nature of the SSGs persisted (i.e. 8 min > 2x4 min > 4x2 min) with high intensity running being the highest in the 2x4min sessions (49.5±21.8 m) vs. 4x2 min (41.7±23.1 m) vs. 8 min (38.3±26.3 m), as shown in table 3. Total distance and changes in speed showed very little variation between conditions. There were trends for a greater number of accelerations in the 4x2 min session (18.1±5.2) compared to 2x4 min (16.7±5.2) and 8 min (15.2±5.0), without reaching significance ($p>0.05$).

4.0 Discussion

This investigation examined the effect of manipulating the exercise to rest ratio within the same SSG duration on both physical and technical outcomes. The main findings of this investigation were a greater subjective feeling of exertion during the continuous eight minute

SSG that interestingly corresponded with the least cumulative high speed distance ran (although not to significance). The eight minute SSG also yielded fewer goals compared with goals scored in the 4x2 minute and 2x4. No significant differences were identified for any of the physical outputs measured via GPS analysis between SSGs. These findings may provide important applied and practical information to support to day-to-day practice in elite players development.

Understanding how SSGs can be adjusted is a key factor when planning training to elicit the correct training response. Although not to significant levels, high intensity distance covered displayed a tendency to be higher in the 2x4 min game compared to the other conditions. Hill-Hass et al. (2009b) found similar results in which moderate and high intensity running was greater when SSGs were split into intervals as opposed to a continuous block. Potentially due to phosphocreatine resynthesis and removal of metabolic waste products during the rest periods (Hill-Haas et al, 2009b). Furthermore, Sampson et al. (2015) investigated the impact of differing interval combinations in SSGs from 1x24 minutes to 24x1 minutes with rugby league players (aged 14-15 years) and found that bouts of shorter duration increased moderate, high and very high distance acceleration activity. Performing high intensity running is vital for success in soccer (Mohr et al., 2003). However, high speed running has been shown to deteriorate significantly towards the end of games (Di Salvo et al., 2007; Mohr et al., 2003), further supporting the need to incorporate these activities within training practices.

Success in soccer is not solely down to a player’s physical prowess, but also a combination of technical/tactical ability, and the ability to maintain these skills throughout the duration of a match. Rampinini et al. (2009) found that match related fatigue influenced the number of short passes a player made as well as their number of individual possessions. This highlights the importance of practicing technical elements of soccer within an environment that is similar to that of a game. Moreover, understanding how manipulating the organisation of SSGs affects these technical outcomes holds large applied importance. In the current investigation the technical actions were only negligibly affected by changes in work to rest ratio. However, significantly more goals were scored in both interval variations as opposed to the continuous session, coinciding with more shots taken. Therefore if a coach wanted to integrate a technical outcome of shooting alongside a physical outcome, the use of shorter intervals may be more appropriate.

Within the literature there are many investigations on SSGs that have examined variables such as number of players and pitch size on technical outcomes. Jones and Drust (2007) found the number of technical actions increased with fewer numbers of players, as player involvement increased. Kelly and Drust (2009) examined the effect of three different pitch sizes on the technical outcomes of a 4v4 SSG, comprised of 4x4 minute blocks. They found that the number of tackles was at its highest on the large pitch, and that number of shots increased with decreasing pitch size. Results from the present investigation and those previously suggested, state that manipulating pitch size, number of players and interval duration and number can have significant effects on technical outcomes. Indeed, Siva et al. (2014) suggested that pitch size is a constraint for tactical behaviours, and needs to be fully considered by coaches when designing training practices.

Energy production during competitive match play has been estimated to be 90% aerobic (Bangsbo, 1994), with a mean and peak HR of 85% and 95% respectively (Bangsbo et al., 2006). However, within the current investigation the mean HR during SSG match-play was significantly below observations by Bangsbo et al. (2006), with mean HR values of 79.4%, 80.2% and 78.1 % for the 8 minute, 2x4 minute and 4x2 minute respectively. However, Bangsbo and Iaia (2013) concluded that SSGs do represent a valid aerobic training stimulus as it has been repeatedly shown that they can elicit a significant increase in HR, RPE and blood lactate. Mean HR reported in the current investigation would suggest that these SSGs should be classified as moderate aerobic training within this population. To achieve high intensity aerobic training, HR response should be predominantly between 80-100%, with a mean of approximately 90%. Contrary to the results of the current investigation, Hill-Haas et al. (2009b) found the continuous session elicited a greater HR response than the interval block, 87% and 84% of maximum respectively. It is important to note that their continuous session was 24 minutes in duration, and their interval block was made up of 4x6 minute bouts, significantly greater durations than those used in this investigation. Therefore, overall duration could be a determinant of exercise intensity. However it is important to note the participants in this current investigation were of a higher training status and more accustomed to the SSG format, possibly contributing to the lower HR response.

Interestingly, it is important to note that in both the current investigation and that of Hill-Haas et al. (2009b) the continuous session was perceived as the hardest by the players, despite similar amounts of locomotor activity and HR. This may potentially suggest an element of central fatigue in a more continuous SSG format. This holds applied relevance, if a player perceives an activity to be easier they may be more motivated by the task and thus increase the external and internal loads. Furthermore perception of fatigue may influence a players pacing strategy. Pacing refers to the management of onset of fatigue through the conscious and unconscious variation in exercise intensity (Edwards and Noakes, 2009), and could explain why in the present investigation minor non-significant differences in locomotor activity and external load were seen between sessions of the same overall duration but differing interval length. Gabbett et al. (2014) investigated the use of pacing strategies with semi-professional rugby players, whereby the players altered their pacing strategy based upon their anticipated end point. When players anticipated a shorter period they started quicker and when they anticipated a longer period they started slower, which resulted in differing results

(Gabbett et al., 2014). As in the present investigation, the players may have employed a time-dependant anticipatory pacing strategy (Sampson et al, 2015). Although there was no deception in this investigation, it could be suggested that players anticipated a longer period in the continuous session and consequently low speed running was greater and high speed running lower.

Pacing is not exclusive to the anticipated end point of exercise. Players may also regulate their efforts when winning (Black and Gabbett, 2014). Something that was observed during the current investigation. When teams were winning and perceived time remaining to be short they attempted to “manage the game”. This was characterised by keeping possession and an obvious attempt to slow the pace of the game. Furthermore, due to the unpredictable nature of team sports there is significant game-to-game variability in activity profiles (Gabbett et al, 2014). As reported in literature, there is more inter-individual variability in SSGs versus generic running drills (Dellal et al, 2008), resulting in a greater level of difficultly in controlling the physical output and response. To account for the game-to-game variability the present investigation would benefit from more samples and trials.

5.0 Conclusion

SSGs provide an effective, holistic training tool that can be used to develop physical, technical and tactical elements of an individual’s game. This investigation demonstrated that manipulation of SSG intervals had no significant effect on GPS derived metrics or HR responses. The only differences highlighted were an increase in RPE during the continuous eight minute bout, which also resulted with a reduced number of goals scored. This lack of significance regarding the physical outputs may be an interesting finding in itself, and may demonstrate that player number and pitch dimensions are the key variables that influence physical output during SSGs.

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