



Soccer Small-Sided Games Activities Vary According to the Interval Regime and their Order of Presentation within the Session

by

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In order to investigate the physical demands of widely used in soccer small-sided games (SSGs), we compared game variations performed under different interval (fixed or variable) and timing regimens (beginning or end of a training session). Twelve male players wore GPS devices during the SSGs to record total distance, relative distance, distance at different speeds, and maximum velocity variables. Four variations of SSGs (4x4) were randomly applied: beginning of a training session with fixed and variable recovery, or end of a training session with fixed and variable recovery. During the beginning or end of a training session settings with fixed recovery duration, 2-min of playing and 2-min of recovery were provided. During the beginning and end of a training session settings with variable recovery, athletes kept playing until a goal was scored, or up to 2-min if no goals were scored. Results were analysed using MANOVA. Total distance and relative distance were higher in the beginning compared to end of training sessions for both fixed and variable recovery duration (small to moderate effect sizes). Distance at various speed ranges (i.e., 13-18 km/h and >18 km/h) was higher ($p \leq 0.01$) at the beginning than at the end of training sessions with variable recovery. In addition, distance >18 km/h was higher at the beginning of a training session with variable recovery than fixed recovery and at the end of a training session with variable recovery than fixed recovery. In conclusion, several physical demand characteristics are affected by the moment of SSG application, while others respond to the recovery regime during SSGs, thus providing indications to the coaches to prescribe the intended training intensity by manipulating the context.

Key words: youth athletes, soccer, game-based training, movement patterns.

Introduction

Studies investigating the physical demands associated with soccer matches have shown that players cover between 10 and 13 km per match (Bangsbo et al., 2006), including a high number of high-intensity activities (150-250 actions) interspersed with recovery periods (Stølen et al., 2005) and specific technical-tactical demands (Rampinini et al., 2009). To cope with

these requirements, players need to develop optimal levels of speed, strength, agility, and aerobic power (Reilly and Gilbourne, 2003), in fine combination with proficiency in ball-related skills and decision-making abilities (Gabbett et al., 2009). Although research has aimed to determine the most effective ways to train team sports players (Bishop, 2009), the great complexity

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characterizing soccer (Morgans et al., 2014) has made this task rather difficult (Aguiar et al., 2012). Nevertheless, there is a high level of agreement that training stimuli need to resemble the competition demands (Gamble, 2008), since more meaningful (and specific) improvements in performance occur when the preparation simulates the physiological and activity characteristics of the match (Gabbett et al., 2009).

Small-sided games (SSGs) are considered a training method which best reproduces the competition context (Aguiar et al., 2012), demanding the key performance factors of modern soccer (Lago-Peñas et al., 2010). These drills allow development of technical-tactical aspects together with relevant physical capacities such as specific endurance, strength-power qualities, and agility in a realistic match-related context (Rebelo et al., 2016). Therefore, SSGs are developed under special rules, which basically involve the participation of a reduced number of players interacting in a space smaller than that set in competition (Rampinini et al., 2007). From this basic structure, coaches can manipulate game variables to achieve desired training results (Hill-Haas et al., 2011). During the last two decades, several studies have investigated the physiological and performance responses associated with different SSG formats (Christopher et al., 2016; Halouani et al., 2014; Hill-Haas et al., 2010). The majority of these studies have focused on manipulation of the pitch size, number of players, motivation of the coach, defensive organization, use of goalkeepers, and use of selected rule changes (Hill-Haas et al., 2011). However, other variables may also affect SSG characteristics and outcomes (Köklü et al., 2015).

Coaches usually make use of SSGs with continuous or intermittent loading fashions depending on the targeted physical capacities (Fanchini et al., 2011; Hill-Haas et al., 2009). When the interval method is implemented, the type and duration of the recovery affect the physical demands of the task (Köklü et al., 2015). This was demonstrated in SSGs using 1, 2, 3, and 4 min of recovery (Köklü et al., 2015) and when recovery periods of 30 or 120 s were used to analyse its effects on knee extensor muscle oxygenation, heart rate, perceived exertion, and task movement demands of a 3x3 SSG (McLean et al., 2016).

Although the duration of the recovery between bouts may affect the demands of the SSGs (Köklü et al., 2015), it has been common to study the effect of different contextual variables without giving importance to the recovery time between the bouts (Dellal et al., 2011; Köklü et al., 2011; Rampinini et al., 2007). This is critical, since in practice coaches deliberately manipulate the effort to recovery ratio during the games in order to obtain desired results, considering not only the physical aspects but also their relationship with technical performance.

For the sake of standardization, the majority of studies have analysed the physical demands of SSGs performed at the beginning of a training session; however, in practice these tasks are performed at different times within the session (Clemente et al., 2014). Previous studies have indicated that the order of the exercises within the session can affect the athlete's acute and chronic training-related responses (Bellezza et al., 2009; Enright et al., 2015; Lloyd and Deutsch, 2008). However, to our knowledge studies comparing the physical demands of SSGs performed at the beginning or end of a training session are lacking. Such knowledge could be valuable to training programming, given that in some cases it is desirable to stress the physical and technical-tactical qualities of the players in a fatigued state (e.g., to simulate the "worst scenario" of matches, when players need to perform well after prolonged match-play) (Mohr et al., 2003).

Therefore, considering the need for practical guidelines to prescribe game-based training, the objective of this study was to compare the physical demands of soccer SSGs performed under different interval (fixed or variable) and timing regimens (beginning or end of a training session). It was hypothesized that SSGs with variable recovery time (established by a "goal scoring rule") and performed at the end of the training session would result in reduced physical demand compared to those in which the recovery was fixed every 2 min and performed at the beginning of a training session.

Methods

Participants

Twelve male junior soccer players (age, 17.2 ± 0.44 years; body height, 1.72 ± 0.5 cm; body

mass, 64.81 ± 7.17 kg) belonging to the same team took part in the study. Participants had experience in soccer training amounting to 8.2 ± 2.3 years. All the players regularly took part in three training sessions per week (90-120 min), in addition to an official regional match on Saturdays. Prior to the start of the study, the club technical staff accepted participation in the study. Subsequently, the players' parents or legal guardians were briefed about the benefits and risks arising from study participation and provided written informed consent for the player's participation. The research design and procedures complied with the standards set out in the Declaration of Helsinki.

Experimental protocol

Players were familiarized with the use of GPS (Global Positional System) units and SSG formats, during 2 weeks prior to the start of the study. The activity characteristics were recorded in 4 training sessions during the competitive period, always at the usual training time of the players (21:00 - 22:30 h) and maintaining at least 48 h of recovery from the last competitive match. Players participated in SSGs wearing their usual training uniforms and soccer boots to play on the artificial grass field on which they normally trained. During the study duration, the players were instructed to maintain their usual habits, which included 8 hours of night-time sleep before each data collection session and optimal hydration and carbohydrate intake over the 24 hours prior to each experimental SSG.

The physical demands of the SSGs were obtained using GPS devices (K-Sport®, Italy) with sampling frequency of 10 Hz. This equipment was previously used in a soccer study (Fernandes-da-Silva et al., 2016) in which acceptable reliability of the referred GPS model was evidenced. The intraclass correlation coefficient at different velocity ranges (including sprinting [>20 km/h]) varied between 0.71-0.99, with corresponding coefficient of variation of 1.3-11.6% (source: K-Sport®, Italy). The GPS devices were inserted in a pocket located in the upper portion of the player's back, inside a vest specifically designed to carry the measurement unit. Activation of GPSs occurred 15 min before starting the training session. Total distance (TD), relative distance (Drel), high-intensity distance (HID >13.1 km/h), and maximum velocity (V_{max}) were recorded. In

addition, the distances were split into six speed ranges: Dv1 = 0-0.4 km/h; Dv2 = 0.5-3.0 km/h; Dv3 = 3.1-8.0 km/h; Dv4 = 8.1-13.0 km/h; Dv5 = 13.1-18.0 km/h; and Dv6 ≥ 18.1 km/h (Castagna et al., 2003). All data were analysed using K-Fitness proprietary software (K-Sport®, Italy).

Small-sided games

Four types of SSGs were randomly applied during the team's regular competition period: at the beginning of the session with fixed recovery (BF) and variable recovery (BV), and at the end of the session with fixed recovery (EF) and variable recovery (EV). On a 40 x 30 m soccer pitch, SSGs were played with four players per team (4x4 matches; 150 m²/player). Three 4-player teams were arranged (A, B, and C). Matches included official goals and goalkeepers. The same players (arranged according to athlete's minutes played in competition, playing position, and subjective evaluation of the coach (Casamichana and Castellano, 2010)), always formed teams A, B, and C. During the BF and EF, teams A and B started by playing for 2 min, while team C rested, acting as the external wildcard (EW) along the sides of the soccer pitch. Next, teams B and C played for 2 min, while team A acted as the EW. Subsequently, teams A and C played for 2 min, while team B acted as the EW. This pattern was repeated for A vs B, B vs C, C vs A, and A vs B. Thus, teams A, B, and C played a total of 10, 10, and 8 min, with recoveries of 4, 4, and 6 min, respectively. In this sense, teams played and rested a fixed amount of time. During BV and EV, the same pattern was used. However, athletes kept playing until a goal was scored, or up to 2 min if no goals were scored. With this sequence, both the playing and recovery time varied according to events of the game. This game format was included to simulate real game situations that are highly prevalent in European teams (e.g., Spain). Therefore, during BV teams A, B, and C played approximately 10.9, 8.3, and 8.8 min, with recoveries of 2.1, 6.2, and 5.7 min, respectively. During EV teams A, B, and C played approximately 10.4, 8.3, and 9.3 min, with recoveries of 3.9, 5.6, and 4.5 min, respectively. Figure 1 illustrates the spatial design of the SSGs.

During BV and EV eleven and ten 4x4 matches were played, respectively. Playing times per playing bout during BV and EV for team A were 86.1 ± 29.8 s and 85.8 ± 18.6 s, for team B 70.7

± 30.6 s and 82.5 ± 31.6 s, and for team C 88.3 ± 31.7 s and 82.9 ± 26.4 s, respectively. Respective recovery times during BV and EV for team A were 62.5 ± 38.9 s and 78.3 ± 42.5 s, for team B 101.3 ± 22.5 s and 86.3 ± 12.5 s, and for team C 74.0 ± 31.3 s and 86.7 ± 25.2 s.

During BF and BV, players completed a warm-up before the SSGs. The warm-up included 5 min of dynamic stretching combined with jogging, 5 min of injury prevention drills (proprioception; coordination; eccentric strength), and 5 min of SSGs 4+4 x 4 on a 20 x 30 m soccer pitch with the aim of ball possession. Before EF and EV, aside from the previously described warm-up, players completed 40 min of 11 x 11 technical-tactical drills on an official soccer pitch.

The coaching staff motivated the players to give their best in all SSGs and 11 x 11 simulations. Technical staff members distributed balls into the goals, so that each time the ball left the pitch, the corresponding goalkeeper quickly introduced a new ball to provide as much continuity as possible to the task.

Statistical analysis

Results are expressed as mean \pm SD. After checking for normal distribution of the data by

means of the Shapiro-Wilk's test and homoscedasticity using the Levene's test, we compared the physical demands of the SSGs performed with different work to rest ratios and at different times of the session, applying MANOVA with the Bonferroni post hoc test to identify where the differences occurred. In addition, the effect size (ES) with 90% confidence limits was calculated using $d < 0.2$ (insignificant); 0.2-0.6 (small); 0.6-1.2 (moderate); 1.2-2 (large); > 2 (very large) (Hopkins et al., 2009). Data analysis was performed with Statistical Software for the Social Sciences (SPSS v. 18.0; SPSS, Inc., Chicago, IL, USA).

Results

Physical demands during SSGs at the beginning versus end of training

Figure 2 shows that TD and Drel were significantly higher ($p \leq 0.05$) in BF compared to EF ($1,116 \pm 78.9$ m and 79.7 ± 5.6 m/min vs $1,073 \pm 118$ m and 76.3 ± 8.4 m/min, respectively). The ES (1.31) indicates that Drel in BV was moderately higher than in EV. The HID in BF (223 ± 56.8 m) was higher ($p \leq 0.01$) than in EF (170 ± 64.1 m).

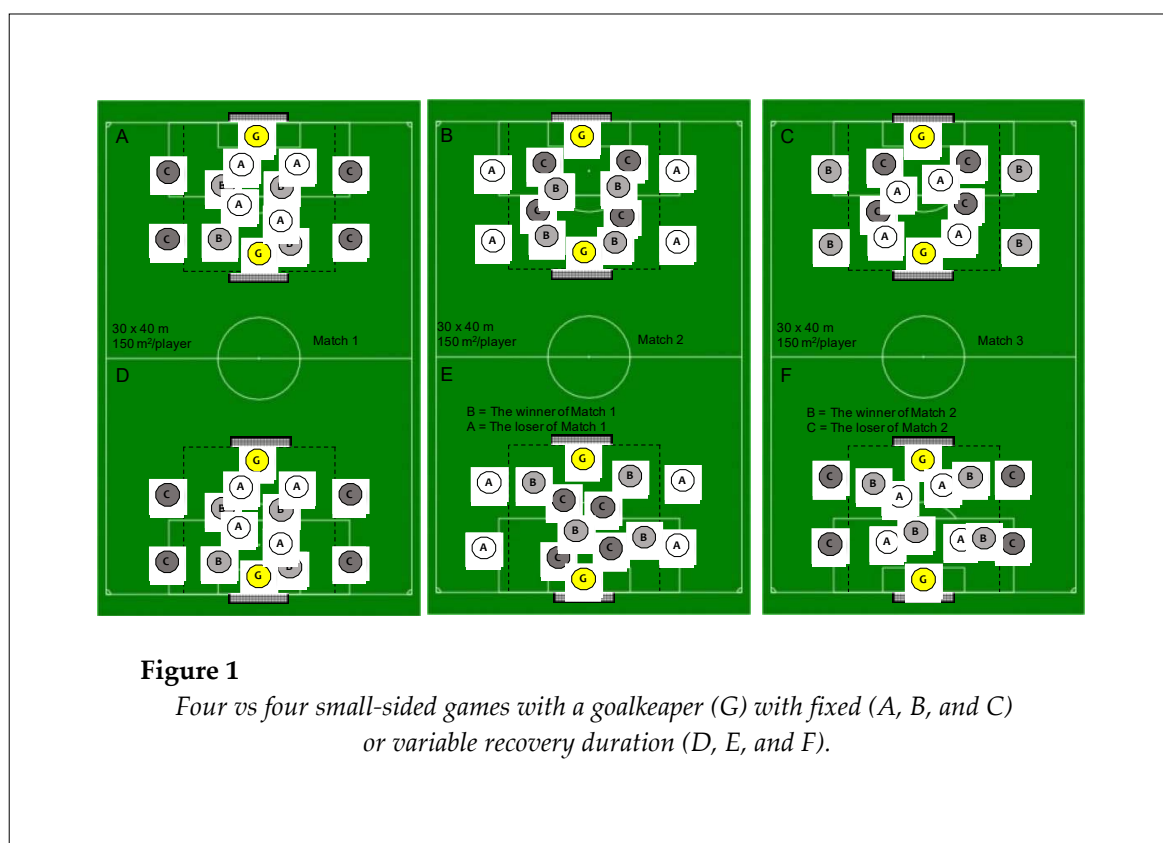


Figure 1

Four vs four small-sided games with a goalkeeper (G) with fixed (A, B, and C) or variable recovery duration (D, E, and F).

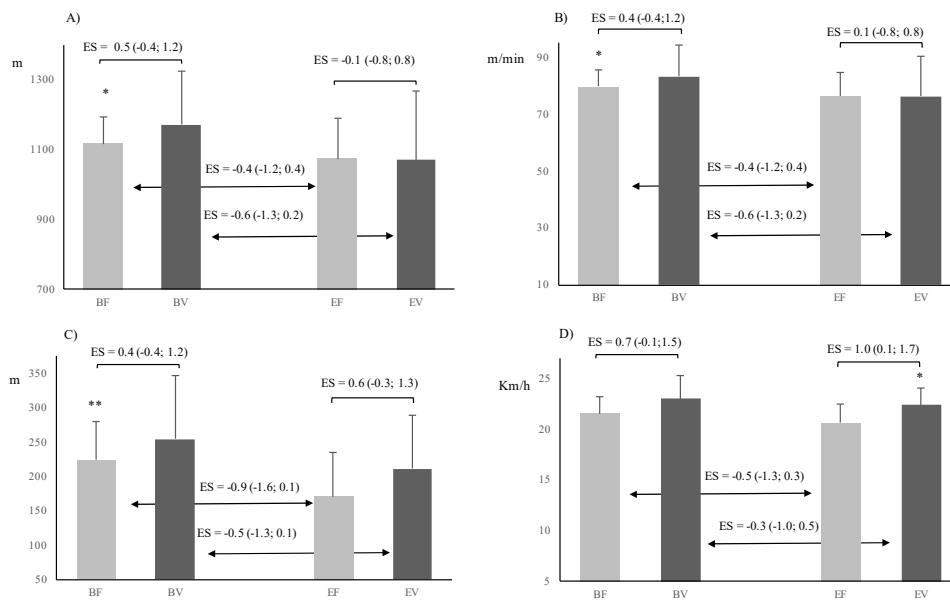


Figure 2

Small-sided games (SSGs) total distance (A), relative distance (B), distance at high-intensity (C), and maximum speed (D). The SSGs were played at: the beginning of the session with fixed recovery (BF) and variable recovery (BV), and the end of the session with fixed recovery (EF) and variable recovery (EV).

ES = effect size (with 90% Confidence limits). *

** Significant differences with EF ($p \leq 0.05$ and $p \leq 0.01$, respectively).

Table 1

Distance (m) covered at different speeds during small-sided games (SSGs).

	BF	BV	EF	EV	ES (90% CL)			
					BF vs BV	EF vs EV	BF vs EF	BV vs EV
Dv1								
(0-0.4 km/h)	6.2±2.2	5.9±1.0	6.1±1.5	6.7±2.1	-0.2 (-1.0; 0.6)	0.3 (-0.5; 1.0)	-0.1 (-0.8; 0.7)	0.5 (-0.3; 1.3)
Dv2								
(0.5-3.0 km/h)	89.2±28.5	88.0±24.0	99.1±23.4	96.5±27.6	-0.1 (-0.8; 0.7)	-0.1 (-0.9; 0.7)	0.4 (-0.4; 1.1)	0.3 (-0.5; 1.1)
Dv3								
(3.1-8.0 km/h)	364.4±69.1	382.2±68.4	413.6±56.6	373.4±74.7	0.3 (-0.5; 1.0)	-0.7 (-1.4; 0.2)	0.8 (-0.1; 1.5)	0.1 (-0.9; 0.7)
Dv4								
(8.1-13.0 km/h)	433.2±60.1	441.2±76.6	383.9±68.6	382.8±114.9	0.1 (-0.7; 0.9)	-0.1 (-0.8; 0.8)	-0.8 (-1.5; 0.1)	0.6 (-1.4; 0.2)
Dv5								
(13.1-18 km/h)	188.5±45.5*	203.5±72.4	150.3±56.7	177.2±62.2	0.3 (-0.5; 1.0)	0.5 (-0.3; 1.2)	-0.7 (-1.5; 0.1)	0.4 (-1.2; 0.49)
Dv6								
(>18 km/h)	34.3±22.5	50.0±31.2	19.9±17.0	33.7±20.2	0.7 (-0.2; 1.3)	0.8 (0.1; 1.5)	-0.7 (-1.5; 0.1)	0.6 (-1.4; 0.2)

SSGs were played at: the beginning of the session with fixed recovery (BF) and variable recovery (BV), and the end of the session with fixed recovery (EF) and variable recovery (EV). ES = Effect size (with 90% confidence limits). * Significant differences with EF ($p \leq 0.05$).

Table 1 shows the distances covered at different speeds. Longer distances were covered at Dv5 ($p \leq 0.05$) in BF than EF. The distances travelled at Dv4 ($ES = 0.76$) and Dv6 ($ES = 0.72$) were moderately higher in BF than EF.

Physical demands during SSGs as a function of interval regimens

Regarding V_{max} , there were no significant differences as a function of the moment of the session, but a higher value ($p \leq 0.05$) was obtained in EV than in EF (22.4 ± 1.7 km/h vs 20.6 ± 1.9 km/h, respectively) (Figure 1 D). In addition, Dv6 was moderately higher in BV than BF ($ES = 0.7$) and in EV than EF ($ES = 0.8$) (Table 1).

Discussion

The objective of this study was to compare the physical demands of SSGs performed under different interval and timing regimens of SSG prescription within a training session. The main results indicate that several dependent variables were affected by the moment of SSG application within the training session, while others responded to the interval regimens used during SSGs, with high-intensity activities being directly affected by these two independent variables. In fact, besides HID, Drel, TD, Dv4, Dv5, and Dv6 were all affected by the moment of SSG application within a training session (beginning or end of the session), with greater physical demands placed in SSGs played at the beginning of training sessions (especially when a fixed recovery period was used). On the other hand, V_{max} and Dv6 were affected by the interval regime used during SSGs, with greater physical demands placed when SSGs were played with a variable recovery period; during EV for V_{max} and during BV and EV for Dv6.

During a match, players are required to perform both in rested and fatigued states. Therefore, SSGs can be used to prepare the players to deal with playing demands in both conditions. In this sense, current results show that if SSGs are applied at the beginning of training sessions, a greater stimulus (TD, Drel, HID, Dv4, Dv5, and Dv6) may be applied to players for their physical development. However, if development of high-intensity activity (e.g., Dv6 and V_{max}) is required under a fatigued state, then SSGs applied at the end of training sessions may be an adequate alternative, while using a variable recovery period

approach. This information could be of critical importance to coaches to adequately prescribe SSGs at the beginning or end of training sessions, considering their differences in terms of physical demands and performance.

Interestingly, HID in BF was greater than in EF. Performing high-intensity runs is a basic stimulus for the player's specific performance during a match (Mohr et al., 2003). The BF can provide this training stimulus to the players, while probably also preserving more the technical aspects of the game compared to EF (Rampinini et al., 2008). On the other hand, to attenuate the reduction in high-intensity activity usually observed toward the end of a match, training must include stimuli that prepare the player to face this situation (Di Salvo et al., 2007; Mohr et al., 2003). In this case, although HID is reduced in EF, players are required to cope with fatigue and still perform high-intensity actions, which might determine match outcomes at the end of a competitive match. This training scheme can be used with concomitant monitoring of physiological (e.g., heart rate) and perceptual responses (Rampinini et al., 2007) in order to deliver adequate training stimuli without excessive fatigue and increased risk of injury (Lehnert et al., 2017).

SSGs are widely used to reproduce match-related physical demands and improve specific endurance performance (Hill-Haas et al., 2009; Impellizzeri et al., 2006). However, their effects on linear sprint performance are not clear (Harrison et al., 2015; Hill-Haas et al., 2009). For this reason, rule manipulations have been proposed in order to more heavily stress the sprinting ability of soccer players during SSGs (Casamichana et al., 2012; Hill-Haas et al., 2010). In this study, a variable recovery time was modulated by the creation of goal scoring opportunities, causing an optimization of V_{max} during SSGs played at the end of training sessions compared to the fixed recovery time at the same moment of the training session. This might be related to the attempt of each player to perform more efficient and sharp attacks to score and subsequently be awarded with a rest period (especially considering they are already fatigued due to the prior training activities). Therefore, the EV can be considered a suitable strategy to train the ability to sprint during decisive match situations, using a

competition-specific contextual factor (or rule) that determines capitalization of between-bouts recovery (i.e., pressure to score). In alternative wording, EV appears to "push" players to perform better to score the goal. Since sprinting is the most common action before decisive moments of the match (goal scoring) (Faude et al., 2012), this seems to be an adequate approach to train key activities of offensive tactical formations.

Conclusions

Understanding the physical demands imposed by different formats of SSGs seems critically important to adjust and optimize training loads and maximize adaptations (while reducing injury risk). In this sense, current findings contribute to the advancement of the

field, showing that some selected physical demands are affected by the moment of SSG application (beginning or end of a training session), while others respond to the type of recovery (fixed or variable) used during SSGs.

In general, the SSGs performed at the beginning of training sessions present higher activity profiles (e.g., total distance and high-intensity distance), especially when fixed intervals are prescribed. Moreover, irrespective of the same moment within the training session (beginning or end), variable recovery periods are more demanding than fixed intervals, especially at high-speed activities. Therefore, these contextual variables should be manipulated by the coach in accordance to his/her aims during the session.

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