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The Effect of Changing Player Numbers on the Physiological Responses and Time-motion Characteristics of a Soccer-Specific Training Drill

Brief Running Head: Soccer-Specific Training Drills

Timothy J. Knight¹, Brendan R. Scott², Farzad Jalilvand³, and Robert G. Lockie³.

¹Central Coast Mariners FC, Tuggerah Lakes, Australia.

²Exercise and Sport Science, School of Environmental and Life Sciences, University of Newcastle, Ourimbah, Australia.

³Department of Kinesiology, California State University, Northridge, Northridge, USA.

Corresponding Author

Robert Lockie

California State University, Northridge

Department of Kinesiology

18111 Nordhoff Street

Northridge, CA 91330

USA

Phone (international): +1 818-677-6983

Fax (international): +1 818-677-3207

Email: robert.lockie@csun.edu

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Abstract

Soccer-specific training (SST) drills are used to develop physiological adaptations, technical and tactical skills, and provide coaches with greater control of external training load. Despite widespread use, there has been little analysis of SST drills. This study quantified the effect of manipulating player numbers on the physiological demands of an SST drill. Fourteen players completed nine trials (3 × 8, 10, 12 players) of a 4-min SST drill modelled on soccer time-motion data. Physiological intensity measures (heart rate, blood lactate concentration [BLa⁻], rating of perceived exertion [RPE]) and GPS time-motion data (movement distances and velocities) were collected for each drill. A repeated measures analysis of variance determined significant ($p < 0.05$) between-drill differences. Results showed variables such as total running distance (TD), mean percentage of maximum heart rate, RPE, and [BLa⁻] were greater for the 8-player SST drill. The 10-player drill also had a 22% greater TD and 21% higher average speed compared to the 12-player drill, which tended to have a lower activity profile. The 8-player SST drill could be used to develop aerobic capacity and repeat-sprint ability (RSA) because of a higher activity profile. The 10- and 12-player drills would be suited for RSA and sprint acceleration enhancement.

Key Words: *football; passing drill; time-motion analyses; conditioning*

1. INTRODUCTION

Soccer is a field-based team sport characterised by its intermittent nature, whereby high-intensity actions are interspersed with longer periods of low-intensity activity (Hoff et al., 2002). These changes in exercise intensity are often accompanied by unconventional movement patterns, such as backwards and lateral running, and the performance of soccer-specific skills (e.g. dribbling and passing the soccer ball) (Little and Williams, 2006). The combination of these movements places a high physiological load on players. As a consequence, training for soccer must be structured to encompass physiological conditioning, coupled with technical and tactical development, in order to properly stress the physical and physiological components required for successful performance (Reilly, 2005). While traditional training methods such as interval running and speed and agility training are widely used, there has been a shift in modern soccer training practice towards more specific conditioning methods (Hill-Haas et al., 2011, Hoff et al., 2002). This includes the use of small-sided games (SSGs) and soccer-specific training (SST) drills, which combine traditional physiological conditioning with technical and tactical development.

SSGs are modified games of soccer played on reduced pitch areas, using adapted rules and decreased player numbers. Due to the ability of SSGs to replicate the movement demands, intensity, and technical requirements of match-play, they could be more advantageous than traditional running-based training practices to enhance the physical fitness of soccer players (Hill-Haas et al., 2011). Nonetheless, the use of SSGs as the primary conditioning tool for players should be treated with caution, as the intermittent nature of SSGs may limit the ability of players to achieve sufficient cardiac load for aerobic fitness adaptations (Hoff and Helgerud, 2004). This has direct ramifications for soccer players at all levels, as a combination of specialised skill requirements (i.e. controlling and passing the ball, while visually scanning for teammates and opponents), in conjunction with physical exertion, can ‘overload’ a player as they are required to process multiple stimuli (Beilock et al., 2002). This could ultimately restrict a player’s ability to reach or maintain the metabolic strain required for physiological adaptations to occur. Thus, SSGs should not be the only skill-based conditioning protocol used in soccer training.

SST drills incorporate skills and movement patterns specific to the sport for which they are designed, and are performed in a relatively closed environment with set activity patterns (Gamble, 2004, Kelly et al., 2013). They are often used in conjunction with SSGs by soccer coaches, and generally aimed at enhancing skills such as dribbling proficiency, passing ability, and shot accuracy. SST drills could also have a dual role in conditioning if properly administered, because they can concurrently train technical skills and develop certain physiological capacities. Indeed, Reilly and Ball (1984) reported running with a ball increased energy expenditure by approximately 8% when compared to running without a ball. This highlights the potentially greater physiological demand associated with SST drills, rather than an equivalent running task without the use of a soccer ball and skill-based element.

In addition to this, unlike SSGs where running demands can be unpredictable, a well-designed SST drill would allow coaches to control the external training load imposed on participants by predetermining the movement patterns and relative intensity of activity.

The potential benefits of this have been shown by McMillan et al. (2005), who observed a 9.4% increase in the maximal aerobic capacity (VO_{2max}) of professional youth soccer players after 10 weeks of ball dribbling around a specifically designed track that incorporated sport-specific movements (i.e. jumping, backwards running, and dribbling) at an intensity of 90-95% of maximum heart rate (HR_{max}). Additionally, Sporis et al. (2008) showed that high-intensity running bouts, coupled with technical drills, increased the VO_{2max} of professional Croatian first league players by approximately 5% over a 13-week period. Taken together, these findings suggest that a well-structured SST drill could be beneficial developing the aerobic and anaerobic capacity of soccer players, as well as concurrently developing the many technical performance facets required by soccer players. Nonetheless, despite their potential benefits and widespread use, questions remain as to whether SST drills can provide appropriate physiological demands to sufficiently condition players (Reilly et al., 2009).

Little research has analysed specifically-designed SST drills (Hoff et al., 2002, McMillan et al., 2005, Sporis et al., 2008), especially those based on time-motion analyses of competitive soccer matches (Kelly et al., 2013). Furthermore, no current research has investigated the effects of manipulating the inherent structure of SST drills. This is likely due to the fact that there are many variations of SST drills, with alterations often implemented by a coach as personal preference. Nonetheless, quantifying the demands of an appropriately designed SST drill would be of great benefit to coaches, allowing them to be used to target particular physiological requirements for soccer. In addition to this, the manipulation of a specific variable such as player numbers may aid in supplementing any conditioning limitations left by SSGs or traditional training, as well as potentially emphasising a specific training goal (i.e. aerobic or anaerobic fitness). Therefore, the aims of the current investigation were to quantify the physiological demands and time-motion characteristics associated with a purposely-designed SST drill when player numbers (8, 10 and 12 players) were manipulated to target soccer-specific adaptations. It was hypothesised that the alteration of player numbers will induce particular physiological and movement demands that allow the SST drill to be used as a training stimulus for parameters including aerobic capacity, repeated-sprint ability (RSA), and maximal sprinting and acceleration.

2. METHODS

2.1 Participants

Fourteen experienced male soccer players (age: 22 ± 4.1 years; height: 1.78 ± 0.05 metres [m]; body mass 76.2 ± 8.0 kilograms) voluntarily participated in this study. The sample size is similar to that used in previous research examining time-motion and physiological responses to SSGs in soccer (Gabbett and Mulvey, 2008, Hill-Haas et al., 2008a, Hill-Haas et al., 2010, Hill-Haas et al., 2009). All participants were 18 years of age or older, were members of the same squad competing in a state-based (New South Wales), Australian domestic soccer competition, and had a minimum of three years playing experience at that level. G*Power software (v3.1.9.2, Universität Kiel, Germany) was used to confirm that the sample size of 14 was sufficient for a repeated measure, within factors analysis, and ensured the data could be interpreted with a power level of 0.8, when significance was set at 0.05 (Faul et al., 2007).

The study occurred during the participants' competition season (Jovanovic et al., 2011, Lockie et al., 2012, Lockie et al., 2014b, Spinks et al., 2007), and they continued their existing physical activity during the study, which generally consisted of 2-3 field- and 1-2 gym-based sessions, and one game, per week. Participants were notified of the research procedures, requirements, benefits, and risks of participation, before providing written informed consent. The project was granted approval by the institutional ethics committee, as well as the coach of the team, and conformed to the policy statement with respect to the Declaration of Helsinki.

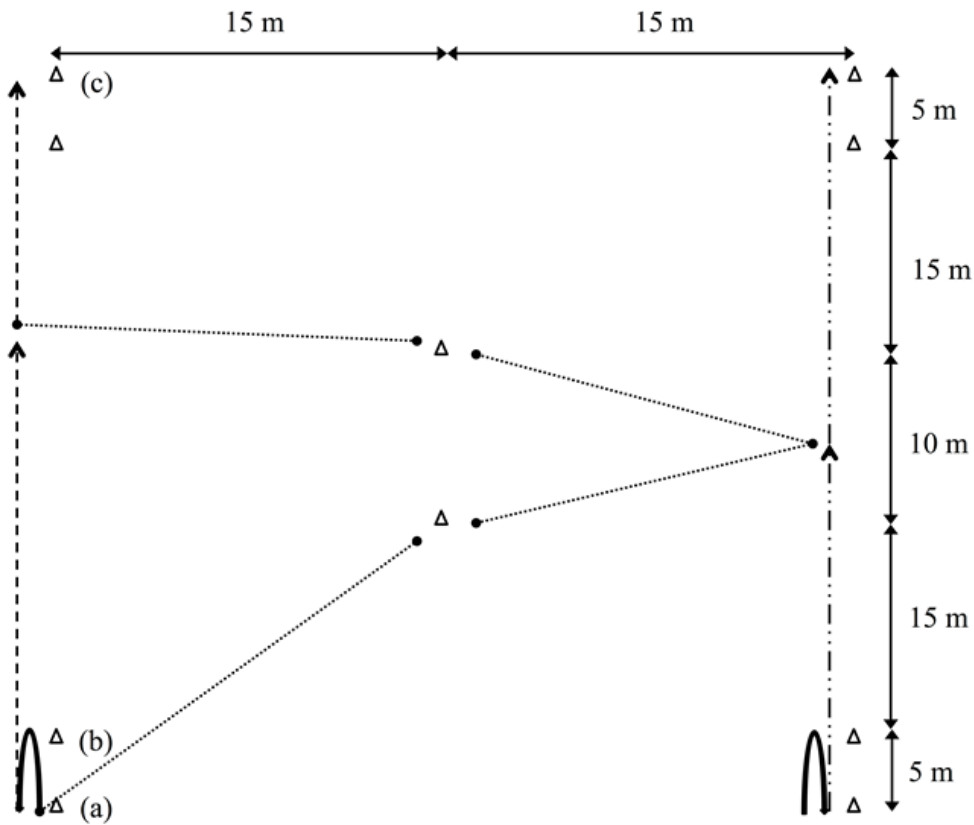
2.2 Procedures

Prior to data collection, each participant's age, body mass and height were recorded. In order to determine the HR_{max} of participants, the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IRT¹) was conducted one week prior to testing as per established methods (Mohr et al., 2003). Participants wore HR devices (Polar Team² System, Polar Electro, Kempele, Finland) that continually monitored HR at 5 second (s) intervals throughout the warm-up and Yo-Yo IRT¹. The results of this test were used to provide measures of relative intensity for each SST drill with all HR data reported relative to HR_{max} . Nine exercise trials of a duration of 4 min, which was in accordance with research on interval training and SSGs (Dellal et al., 2008, Kelly and Drust, 2009), were completed under the following conditions: 3 x 8 players; 3 x 10 players; and 3 x 12 players. Each testing session was separated by one week approximately three days after competition match-day, with the order being randomised. All SST drills were performed outdoors on a natural grass surface at the same time of day, on days of similar environmental conditions. Participants were required to wear their normal playing attire, which consisted of soccer boots and appropriate clothing for exercise.

In order to ensure consistency with results, a standardised 15-minute (min) warm-up was performed prior to each SST drill, which consisted of low-intensity running, dynamic stretching involving the major muscles of the legs, back and trunk, and moderate-intensity running. The warm-up did not involve any ball work and was completed concurrently by all participants. The SST drill was conducted immediately following the standardised warm-up. Physiological and perceptual measures including heart rate (HR), blood lactate concentration ([BLa]), and rating of perceived exertion (RPE) were recorded, as well as the movement demands of the SST drills (particularly fast running and sprinting) using global positioning system (GPS) technology.

2.3 Soccer-Specific Training Drill

The structure of the SST drill was designed to replicate the technical (i.e. passing and controlling the ball) and movement demands (i.e. linear sprints and changes of direction) of soccer match-play (Figure 1). The drill was set at a length of 50 m. This allowed for the inclusion of efforts replicating the common length and duration of sprints during match-play (Andrzejewski et al., 2013, Greig et al., 2006, Spencer et al., 2005). This was confirmed during preliminary testing prior to the commencement of the study. The SST drill was also structured to place sufficient physiological stress on players to make it comparable to SSGs involving a similar number of players and pitch dimensions (Dellal et al., 2008, Hill-Haas et al., 2010, Hill-Haas et al., 2009, Rampinini et al., 2007b). The SST drill dimensions were the same for each testing occasion, and all distances were measured via a standard tape measure (HART Sport, Aspley, Australia).



-----> Player 1 running path •.....• Path of ball - · · · -> Player 2 running path

Figure 1. A soccer-specific training (SST) drill. Players follow the route indicated by arrows. Players perform a return shuttle run between points (a) and (b) and a maximal speed run between points (a) and (c). Δ = Cone. NB: Not to scale.

Participants performed the SST drill in pairs, and these pairs were kept consistent across each testing session. The design of the drill allowed two pairs of participants to complete it in opposite directions simultaneously, thus providing either a continuous or intermittent workload depending on the number of players involved. The SST drill required participants complete as many repetitions as possible within the allocated 4 min. A large number of balls were placed at each end of the SST drill to ensure quick replacement following any misguided passes. To encourage a high work rate, the researchers and team coaching staff provided verbal encouragement to all participants for the duration of the drill. The SST drill was initiated when all players were in their starting positions, and the researcher indicated that time had started.

2.4 Player Numbers

This study involved three separate protocols of the SST drill of which 8, 10, and 12 players were used within the drill. Two players were located in the middle of the drill for all variations of the SST drill to assist ball movement, but were not included in analysis. The 8-player protocol was the minimum number of players needed to facilitate the drill, designed to potentially target the aerobic capacity of players, and matched previous research analysing SSGs using a 4v4 format (Hill-Haas et al., 2008b). Following analysis of previous studies utilising large SSGs (Hill-Haas et al., 2008a,

Rampinini et al., 2007b), the 12-player SST drill was set as the maximum number of players required to adequately elicit an aerobic training response, and also matched SSGs formats of 6v6 players (Hill-Haas et al., 2008a). The 10-player SST drill provided an intermediary condition to the range established by the 8- and 12-player formats, matched the 5v5 SSG format (Coutts et al., 2009, Rampinini et al., 2007b), and was devised to potentially target the RSA capabilities of players.

2.5 Physiological Data

Prior to commencing the warm-up, participants were fitted with a HR device, which continually monitored HR at 5-s intervals throughout the experimental trial. HR data were stored internally within the monitors and later downloaded into the Polar Team² software. These HR data were then categorised into five different intensity zones relative to percentage of maximal HR (%HR_{max}), in accordance with Hill-Haas et al. (2009); 50-59%HR_{max}; 60-69%HR_{max}; 70-79%HR_{max}; 80-89%HR_{max}; and 90-100%HR_{max}.

Capillary blood samples (5 µL) were drawn from a hyperaemic earlobe immediately following completion of the SST drill, and were analysed using a Lactate Scout (EKF Diagnostics, Magdeburg, Germany) to determine [BLa]. Blood samples were taken from all participants in the SST drill excluding the two players in the centre, and were drawn in the same order following each SST drill (Hill-Haas et al., 2008a, Rampinini et al., 2007b).

2.6 Perceptual Data

Given that the SST drill was performed as a single component of an entire training session, the collection of perceptual responses 30 min following exercise (Foster et al., 2001), was not possible. Therefore, instantaneous RPE using the Borg Category Ratio-10 (CR-10) scale was taken immediately following the SST drill. This method has previously been used in the analysis of perceptual responses to physical activity in team sports (Elsworthy and Dascombe, 2011), and the CR-10 scale has been adopted in previous soccer research (Casamichana and Castellano, 2010, Coutts et al., 2009, Impellizzeri et al., 2004, Rampinini et al., 2007b). Prior to the commencement of the study, players were familiarised with the CR-10 RPE scale, and provided with standardised anchoring procedures. RPE values were collected individually to eliminate any influence from other participants.

2.7 Time-Motion Data

Player movements during the SST drill were measured using portable MinimaxX GPS units, sampling at 5 Hertz (Firmware v6.59; Catapult Innovations, Scoresby, Australia). These units are frequently used to monitor team sport athletes due to their portability, relatively inexpensive costs and easy analysis (Aughey, 2011, Portas et al., 2010). The GPS unit was placed into an undergarment that positioned the device between the scapulae of the player. Immediately following the SST drill, the GPS units were removed from the undergarment, powered off, and stored for later data download and analysis. Data from the GPS units were downloaded to a personal computer using Logan Plus software (v4.4.0, Catapult Innovations, Scoresby, Australia). Each file was manually cropped to include only data from the SST drill. The data was then transferred into a Microsoft Excel (Microsoft CorporationTM, Redmond, Washington, USA)

spreadsheet for storage and analysis. Erroneous data was removed when a horizontal dilution of position value greater than five was observed, or when less than five satellites were available.

In accordance with previous research, velocity zones were established to calculate distance covered and time spent in various locomotor categories (Coutts et al., 2010, Elsworthy and Dascombe, 2011, Rampinini et al., 2007a, Rampinini et al., 2009). The categories were: standing ($<0.7 \text{ km}\cdot\text{h}^{-1}$); walking ($0.7\text{-}7.0 \text{ km}\cdot\text{h}^{-1}$); jogging ($7.0\text{-}14.4 \text{ km}\cdot\text{h}^{-1}$); running ($14.4\text{-}20.0 \text{ km}\cdot\text{h}^{-1}$); fast running ($20.0\text{-}23.0 \text{ km}\cdot\text{h}^{-1}$); and sprinting ($>23.0 \text{ km}\cdot\text{h}^{-1}$). These movement categories were also grouped into low-speed running (LSR; $<14.4 \text{ km}\cdot\text{h}^{-1}$) and high-speed running (HSR; $>14.4 \text{ km}\cdot\text{h}^{-1}$). The total distance (TD) travelled, and average speed ($\text{m}\cdot\text{min}^{-1}$) for each drill was also calculated.

2.8 Statistical Analyses

The statistical analysis for this study was modelled on that of Hill-Haas et al. (2009). Descriptive statistics were calculated for all data and are reported as mean \pm standard deviation. A repeated measures analysis of variance was performed on each dependent variable including HR, RPE, [BLa], and the various time-motion characteristics. The independent variable was the SST drill format. In the event of a significant F -ratio, Bonferroni post hoc analysis was conducted for pairwise comparisons to establish the extent of significant findings, which was set at $p < 0.05$. Effect sizes (d) for selected variables were also calculated by dividing the means by the pooled standard deviations (Cohen, 1988). An d less than 0.2 was considered a trivial effect; 0.2 to 0.6 a small effect; 0.6 to 1.2 a moderate effect; 1.2 to 2.0 a large effect; 2.0 to 4.0 a very large effect; and 4.0 and above an extremely large effect (Hopkins, 2004). All statistical analyses were computed using the Statistics Package for Social Sciences (v19.0.0, IBM Corporation, New York, USA).

3. RESULTS

Table 1 displays the time spent and distance covered in different locomotor categories for each of the 8-, 10-, and 12-player SST drills. The duration spent at speeds below $0.7 \text{ km}\cdot\text{h}^{-1}$ in the 12-player SST drill was significantly more than both the 8-player and 10-player SST drills ($p < 0.01$; $d = 3.1$ and 1.7 , respectively). Additionally, players in the 12-player SST drill spent a significantly greater duration completing LSR when compared to the 8-player SST drill ($p < 0.01$; $d = 2.9$), and less time jogging ($p < 0.01$; $d = 2.7$) and fast running ($p = 0.02$; $d = 1.0$). There were no significant differences in the total time spent sprinting or HSR.

Table 1. Time spent and distance covered (mean \pm standard deviation) in different locomotor categories, average speed, and work:rest ratios during 8-, 10-, and 12-players variations of a soccer-specific training drill in experienced soccer players.

Time-Motion Variable	8 Players		10 Players		12 Players	
	Duration (s)	Distance (m)	Duration (s)	Distance (m)	Duration (s)	Distance (m)
Stand (<0.7 km·h ⁻¹)	71 \pm 19	24.1 \pm 6.1	102 \pm 15	21.0 \pm 6.8	133 \pm 21 ^{a,b}	24.3 \pm 4.5
Walk (0.7-7 km·h ⁻¹)	47 \pm 9	86.7 \pm 19.3	43 \pm 10	63.1 \pm 15.3	29 \pm 13	49.3 \pm 18.8 ^a
Jog (7-14.4 km·h ⁻¹)	69 \pm 11	220.1 \pm 30.1	49 \pm 13	152.3 \pm 39.4 ^a	38 \pm 12 ^a	112.4 \pm 36.3 ^a
Run (14.4-20 km·h ⁻¹)	37 \pm 7	165.4 \pm 24.2	32 \pm 7	152.4 \pm 28.8	31 \pm 5	145.0 \pm 27.2
Fast Run (20-23 km·h ⁻¹)	9 \pm 3	48.3 \pm 20.5	10 \pm 5	57.6 \pm 30.2	7 \pm 4 ^a	38.3 \pm 22.0 ^a
Sprint (>23 km·h ⁻¹)	4 \pm 2	27.2 \pm 18.6	3 \pm 5	20.6 \pm 29.1	2 \pm 2	12.9 \pm 14.1
LSR (<14.4 km·h ⁻¹)	187 \pm 4	331.0 \pm 45.7	195 \pm 12	236.3 \pm 40.9 ^a	200 \pm 6 ^a	186.0 \pm 53.8 ^a
HSR (>14.4 km·h ⁻¹)	50 \pm 6	241.1 \pm 44.3	45 \pm 12	230.6 \pm 60.9	40 \pm 6	196.1 \pm 37.9
Total distance	572 \pm 74		466.9 \pm 54		382.1 \pm 39.5 ^{a,b}	
Average speed (m·min ⁻¹)	148.1 \pm 17.2		118.0 \pm 13.6		97.2 \pm 10.2 ^{a,b}	
Work:rest Ratio	1:2.4		1:3.3		1:4.4	

LSR = Low speed running; HSR = High speed running; ^aSignificantly different to 8-player SST drill; ^b Significantly different to 10-player SST drill.

The TD covered walking in the 12-player STT drill was significantly less than that for the 8-player drill ($p = 0.04$; $d = 2.0$). There was significantly less distance covered jogging in both the 10-player ($p = 0.04$; $d = 1.9$) and 12-player ($p < 0.01$; $d = 3.2$) SST drills when compared to the 8-player drill. There was also less distance covered fast running in the 12-player SST drill when compared to the 8-player SBTD ($p = 0.04$; $d = 0.5$). The mean TD covered in the 12-player SST drill was significantly less than both the 8- ($p < 0.01$; $d = 1.8$) and 10-player ($p = 0.03$; $d = 3.2$) SST drills. There was a large effect between the 8- and 10-player SST drills ($d = 1.8$), but this was not significant. Average speed for both the 8- and 10-player SST drills were significantly greater than the 12-player SST drill ($p < 0.01$; $d = 3.6$ and 1.7 , respectively). There were no significant differences in work:rest ratio between the drills.

The fast running and sprinting characteristics of the SST drills were analysed further, and this data is shown in Table 2. No significant differences were found in the mean, minimum, or maximum fast running and sprinting effort durations or distances between any of the SST drills. Moderate effects were seen between the 8- and 12-player SST drills for mean fast running duration ($d = 0.9$) and distance ($d = 0.6$); minimum fast running duration ($d = 0.7$) and distance ($d = 0.6$); and mean ($d = 0.7$), maximum ($d = 0.8$), and minimum ($d = 0.7$) sprint distance. Moderate effects were also observed between the 8- and 10-player drills for mean fast running duration ($d = 0.7$); and mean ($d = 0.9$), maximum ($d = 0.6$), and minimum ($d = 0.9$) sprint distance. Nevertheless, as stated, none of these comparisons were statistically significant.

Table 2. Time spent and distance covered (mean \pm standard deviation) fast running (20-23 km·h⁻¹) and sprinting (>23 km·h⁻¹) during 8-, 10-, and 12-player variations of a soccer-specific training drill in experienced soccer players.

Time-motion variable	8 Players		10 Players		12 Players	
	Duration (s)	Distance (m)	Duration (s)	Distance (m)	Duration (s)	Distance (m)
Mean fast running	2.29 \pm 0.49	12.86 \pm 3.24	1.86 \pm 0.70	12.43 \pm 2.38	1.71 \pm 0.76	11.00 \pm 3.11
Maximum fast running	3.14 \pm 0.38	17.43 \pm 5.53	3.00 \pm 1.00	18.86 \pm 5.64	2.86 \pm 1.68	16.00 \pm 9.13
Minimum fast running	1.57 \pm 0.79	9.29 \pm 4.27	1.29 \pm 0.49	8.43 \pm 1.27	1.14 \pm 0.38	7.29 \pm 1.60
Mean sprint	1.57 \pm 0.79	13.23 \pm 6.73	1.14 \pm 1.07	7.00 \pm 6.68	1.14 \pm 1.35	8.00 \pm 8.96
Maximum sprint	2.00 \pm 1.15	16.00 \pm 9.02	1.71 \pm 1.38	10.43 \pm 9.11	1.23 \pm 1.60	8.71 \pm 10.27
Minimum sprint	1.43 \pm 0.53	11.86 \pm 4.81	1.29 \pm 0.95	7.29 \pm 5.22	1.00 \pm 1.15	7.29 \pm 7.89

Table 3 displays the HR data from each SST drill. The mean %HR_{max} recorded for the 12-player SST drill was significantly less than the 8-player drill ($p = 0.02$; $d = 2.2$). No significant differences were found in relation to the percentage of time spent at different exercise intensities except for 70-79%HR_{max}. Players performing the 12-player SBTD spent significantly less time at the 70-79%HR_{max} intensity than those performing the 8-player SBTD ($p < 0.01$; $d = 1.5$). Interestingly, players in the 8-player SBTD did not record HR values in the 50-59%HR_{max} intensity zone.

Table 3. Relative time spent in HR-based intensity zones (mean \pm standard deviation) during a soccer-specific training drill using 8-, 10-, and 12-player variations in experienced soccer players.

	8 players	10 players	12 players
%HR _{max}	84.1 \pm 4.1	77.5 \pm 3.5	71.4 \pm 7.2 ^a
%Time 50-59%	0.0 \pm 0.0 ^b	2.9 \pm 2.5 ^a	14.9 \pm 19.3
%Time 60-69%	3.8 \pm 5.1	11.2 \pm 8.2	18.8 \pm 16.1
%Time 70-79%	19.3 \pm 14.4	43.5 \pm 26.3	46.0 \pm 20.0 ^a
%Time 80-89%	54.0 \pm 21.3	40.2 \pm 24.1	20.1 \pm 20.2
%Time 90-100%	22.9 \pm 25.5	2.2 \pm 6.1	0.3 \pm 0.7

%HR_{max} = percentage of maximum heart rate; ^aSignificantly different to 8-player SST drill; ^bSignificantly different to 10-player SST drill.

Mean [BLa] and RPE responses to each SST drill are shown in Figure 2. The [BLa] response following the 12-player SST drill was significantly lower than both the 8- ($p = 0.01$; $d = 0.7$) and 10-player ($p = 0.02$; $d = 0.5$) SST drills. Significant differences in RPE measures were also found between the 8-player SST drill and both the 10- ($p = 0.01$; $d = 0.9$) and 12-player ($p < 0.01$; $d = 1.3$) SST drills. No significant differences were found between the 10- and 12-player SST drills.

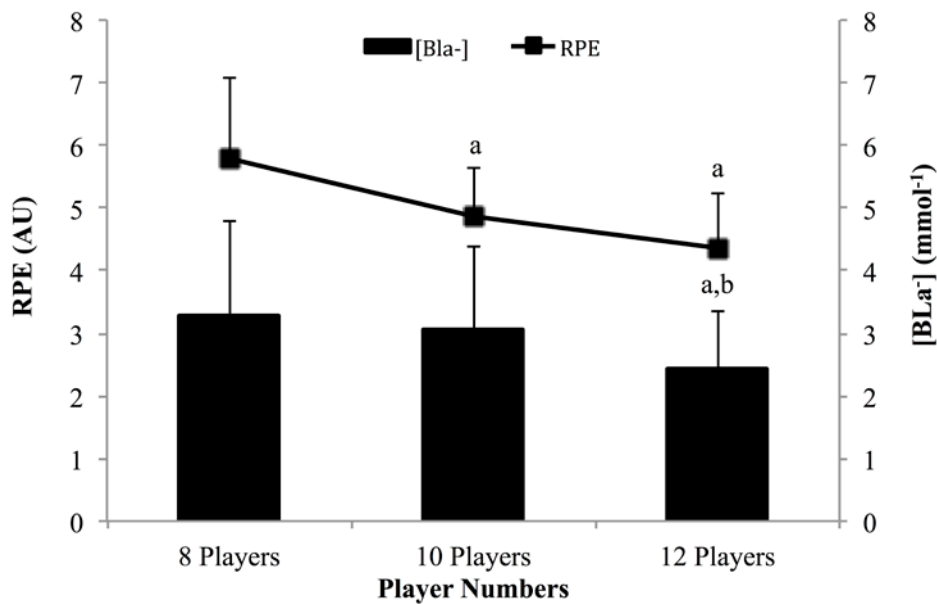


Figure 2. Blood lactate concentration ($[BLa^-]$) and ratings of perceived exertion (RPE) responses (mean \pm standard deviation) following 8-, 10-, and 12-players variations of a soccer-specific training (SST) drill in experienced soccer players. ^aSignificantly different to 8-player SST drill; ^bSignificantly different to 10-player SST drill.

4. DISCUSSION

The aim of this study was to quantify the physiological demands and time-motion characteristics of a SST drill when player numbers were manipulated. Few studies to date have investigated SST drills, despite their popularity in team sport conditioning (Hoff et al., 2002, Kelly et al., 2013, McMillan et al., 2005). With regards to soccer, the physiology of SSGs have been widely analysed, and one of the greatest challenges of employing SSGs in training is maintaining equality in external training load amongst players (Dellal et al., 2008, Hill-Haas et al., 2011). The SST drill from the current study was designed to address this limitation by ensuring all players performed movements that were pre-determined, theoretically placing all players involved under a similar external load. The major finding of the current investigation was an overall reduction in the physiological and perceptual responses to the SST drill as player numbers increased. More importantly, the results suggest that an SST drill based on time-motion analyses of match-play could be used to target specific outcomes in soccer players, and this has direct implications for training in this sport.

The 8-player SST drill tended to feature a higher work rate than the drills with more players. Less time was spent walking, more time was spent jogging and running, greater distance covered was covered LSR, and there was a higher TD and average speed during the 8-player drill (Table 1). A high level of fast running and sprinting was also completed in the 8-player SST drill (Table 2), over distances (approximately 10-20 m) specific to the sport (Andrzejewski et al., 2013, Greig et al., 2006, Spencer et al., 2005). This workload was reflected in the physiological data; the 8-player SST drill elicited a greater HR response than the 10- and 12-player drills (Table 3), and these data were comparable to HR responses of a similar sized SSG. Hill-Haas et al. (2009) reported the physiological intensity of a 4v4 SSG to be equivalent to $84 \pm 4 \%HR_{max}$, which is

almost identical to that measured in the 8-player drill. Furthermore, players involved in the 8-player SST drill also spent a large percentage of time above 80%HR_{max} when compared to both the 10- and 12-player drills, and did not spend any time below 59%HR_{max}. This reflects a high level of physical activity, which was also evidenced by the [BLa] and RPE responses that were greater for the players after the 8-player SST drill (Figure 2).

As high HR responses are important for improving aerobic fitness (Rampinini et al., 2007b), the results of this study suggest the 8-player SST drill may provide a sufficient stimulus to enhance this capacity specific for soccer players. Furthermore, due to the control of movement demands that a SST drill can allow, the average speed of the 8-player SST drill ($148.1 \pm 17.2 \text{ m}\cdot\text{min}^{-1}$) was greater than that recorded by Casamichana and Castellano (2010) ($113.6 \pm 3.8 \text{ m}\cdot\text{min}^{-1}$) for a 50 x 35 m SSG, and Hill-Haas et al. (2010) ($110 \pm 8 \text{ m}\cdot\text{min}^{-1}$) for a 47 x 35 m SSG. The practical application for soccer and strength and conditioning coaches is that if they wish to enhance the fitness of their players by using SST drills, reducing the number of players, while using dimensions similar to the drill from this study, should prove beneficial. In addition to this, due to the lower time spent completing lower-intensity activity while still performing a number of fast runs and sprints (Dellal et al., 2012), and the greater control of the number of higher intensity efforts, the 8-player SST drill could be used to enhance RSA.

Indeed, an important physiological trait of successful soccer players is RSA, as this encompasses the capability to repeatedly perform repeat short high-intensity sprints (Bishop et al., 2011, Dellal et al., 2010, Serpiello et al., 2011). A number of studies have examined the RSA of team sport athletes, using maximal sprint efforts lasting approximately 5 s, interspersed with recovery periods between 40-56 s (Bishop et al., 2001, Fitzsimmons et al., 1993, Impellizzeri et al., 2008, Spencer et al., 2005). Although the durations observed in the aforementioned RSA studies are greater than the duration of efforts observed in the SST drills from this study, so too were the rest periods interspersing such efforts. When the work:rest ratios were considered (Table 1), rather than just the effort duration alone, the activity performed during each of the SST drill variations in the current research mirror the established data on RSA in athletes. The results from this study indicate that the 8-player SST drill provided intensities that would be appropriate for harder training sessions (i.e. during the latter stages of pre-season, and in-season when soccer and strength and conditioning coaches want to implement a higher intensity session).

In addition to the 8-player SST drill, the development of RSA could be a focus of the 10- and 12-player drills. There were fewer differences in time-motion characteristics when comparing these two drills (Table 1), and both featured mean, maximum, and minimum sprints distances that were approximately 10 m (Table 2). Previous research has established the value of speed over this distance for team sport athletes (Lockie et al., 2011, Lockie et al., 2013). When considering the 10- and 12-player SST drill variations, the 10-player drill may feature a more appropriate design for RSA development. The 10-player SST drill led to a 22% greater TD and a 21% higher average speed when compared to the 12-player drill. There was also a higher [BLa] response following the 10-player SST drill, indicating a higher anaerobic workload (Hill-Haas et al., 2009). The practical application for soccer and strength and

conditioning coaches is that they could use an SST drill such as the 10-player version from this study to place an emphasis on RSA development, which for suitable implementation across pre- and in-season periods. The time spent completing lower-intensity activities was reduced, placing a relatively greater emphasis on high-intensity actions such as fast running and sprinting.

Another important consideration for team sport athletes is the ability to accelerate (Lockie et al., 2011, Serpiello et al., 2011). Soccer players complete many direction changes during a match (Bloomfield et al., 2007), and frequent accelerations and decelerations combine to stress the anaerobic capacity of players (Serpiello et al., 2011). This was a feature of the SST drill design from this study (Figure 1). The development of maximal acceleration and the ability to change direction effectively could be of particular relevance to the 12-player SST drill. As previously noted, this drill had lower activity levels when compared to the 8- and 10-player drills (Tables 1 and 3; Figure 2). The lower average speed for the 12-player SST drill also reflects the greater duration of lower-intensity activity, and this phenomenon is similar to SSGs with a higher number of participants (i.e. 6v6 SSGs) (Hill-Haas et al., 2009). The inherent structure of the 12-player SST drill is more reflective of traditional sprint acceleration training, which tends to feature longer recovery periods between sprint efforts (Lockie et al., 2014a, Lockie et al., 2012, Spinks et al., 2007). An SST drill that features more players could potentially be used to target maximal sprint acceleration and direction changes, as longer recovery periods between high-intensity efforts could assist with attenuation the effects of fatigue decreasing performance. In addition to this, a SST drill with greater player numbers could be used early in pre-season, or with players with lower conditioning levels, due to the relatively lower intensity of effort required. For players with better conditioning, SST drills with greater player numbers could be used during sessions that have been periodised to feature lower intensity activities (e.g. recovery-focused training sessions).

Despite there being variations in the physiological workload between the drills, there were no significant differences in the mean, maximum, and minimum fast running and sprinting durations and distances (Table 2). As stated previously, there were some moderate effects, particularly between the 8- and 12-players SST drills for sprint distances. The data suggested that sprint distances in the 8-player drill tended to be longer, which may be expected given the higher intensity level associated with this drill. This further emphasises how the 8-player SST drill could be used to enhance aerobic fitness for soccer. In contrast, the sprints performed within the 10- and 12-player SST drills tended to be shorter, which is more reflective of sprints performed during a soccer match (Andrzejewski et al., 2013). This in turn highlights the specificity of these two drills in potentially targeting RSA and acceleration for soccer. The lack of significance regarding fast running and sprinting differences could be associated with GPS limitations in measuring high-speed movements (Barbero-Alvarez et al., 2010, Coutts and Duffield, 2010, Portas et al., 2010). Soccer and strength and conditioning coaches should be cognizant of this when interpreting time-motion data from SST drills.

In addition to the GPS data, there are other limitations for this research that should be acknowledged. Only a single 4 min bout of exercise was investigated, and any training effects of the SST drill cannot be confirmed by until further longitudinal analysis. In addition to this, Kelly and Drust (2009) showed that HR response to SSGs significantly

increased in successive bouts, indicating an elevated workload experienced by players. Future research should assess the physiological responses to successive bouts of each of the SST drills. Although the movement and physiological characteristics of the SST drills were assessed in this research, the technical responses were not quantified. It may be of benefit to analyse the number of ball contacts (Jones and Drust, 2007), or some other measure of skill execution such as accuracy of passes (Malina et al., 2005, Russell et al., 2010), within the SST drill.

5. CONCLUSIONS

The results from the current study highlight that an appropriately designed SST drill could be used to effectively train a range of soccer-specific adaptations in players. Depending on the goals of the soccer and strength and conditioning coaches, player numbers within an SST drill can be varied to target specific physical capacities, such as aerobic capacity or RSA development. Lesser player numbers (e.g. an 8-player SST drill) will increase the intensity of a drill, making it suitable for harder training sessions implemented during pre- and in-season. A higher number of players (e.g. a 12-player SST drill) can increase the recovery afforded to players between high-intensity efforts, and are suitable for recovery-based sessions for players with higher fitness levels, or conditioning sessions for players who are not as fit. An intermediate SST drill, such as the 10-player drill from this study, could be used across a soccer season to target RSA development.

6. PRACTICAL APPLICATION

The practical application for soccer and strength and conditioning coaches is that they can implement SST drills similar to the one from this study with the understanding that varying player numbers will change the physiological workload experienced by players in a sport-specific manner. Additionally, each version of the SST drill has the advantage of providing greater control of the external workload performed by players. The 8-player SST drill from this study could be used to elicit sufficient demands for improving aerobic capacity and RSA in soccer players, and is suitable for high-intensity sessions implemented during the pre- and in-season. The 10- and 12-player SST drills could also be implemented by coaches to target RSA across different periods of the training cycle for a soccer player. Additionally, the 12-player drill, which had a structure that led to longer recoveries between efforts, could be adopted by coaches when they wish to place a higher emphasis on maximal sprint acceleration, or recovery due to longer durations between efforts.

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