THE PHYSICAL AND TECHNICAL EFFECTS OF MANIPULATING THE PLAYING DIMENSIONS DURING SOCCER SMALL SIDED GAMES

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School of Sport and Recreation

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ATTESTATION OF AUTHORSHIP

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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ABSTRACT

The aim of this study was to determine the acute effects of manipulating the pitch dimensions on the physical and technical responses during small-sided games (SSGs) of young developing female soccer players. Thirteen young female soccer players (mean ± *SD*: age 16.2 ± 1.2 years, body mass 59.3 ± 6.6 kg, height 166.2 ± 6.5 cm and V_{O2} max 45.2 ± 1.7 ml.kg.min^{-1}) participated and played 3v3 and 4v4 SSGs using two different length: width ratios for the pitch dimensions: 1: 1 and 1: 1.3. Each game was played during regular training sessions for 4 × 4 min interspersed with 2 min of passive recovery, following a standardised warm-up. Heart rate (HR) response, time-motion outputs and technical performance was measured continuously throughout all games. The playing intensity during 3v3 SSGs was significantly greater ($p < 0.05$) compared to 4v4 SSGs for mean HR (ES = 1.51), work-rate (ES = 1.24), efficiency index or Eff. Index (ES = 1.10), high-speed distance (ES = 1.32), high deceleration distance (ES = 0.73), and peak velocity (ES = 1.04). The 1: 1 playing area resulted in significantly ($p < 0.05$) larger work-rates (ES = 0.54), Eff. Index (ES = 0.78) and Player Load (ES = 0.27) only compared to the 1: 1.3 playing area. Regarding the technical analysis, the players had an average of 1.2-1.5 involvements.min^{-1} with no significant effect of player number or length: width ratio. The typical outcome of the players' individual possessions was rated as being only 'slightly effective' in all game formats. Finally, there was substantial variation in the number of individual involvements per minute with CVs of 38-43%. In conclusion, the acute physical and technical responses of young female soccer players were relatively low compared to previous findings reported in the literature with males. The length: width ratio had minimal influence on physical and technical outputs of players. However, player number during SSGs was influential for physiological and time-motion demands suggesting that it would be the more important variable to consider when prioritising physical development.

CHAPTER 1: INTRODUCTION

Small-sided games (SSGs) have been widely used within the training sessions of different team sports. S. V. Hill-Haas, Dawson, Impellizzeri, and Coutts (2011) defined SSGs as games played on a reduced area and/or with less players compared to official match conditions. The majority of studies have focussed on soccer (Aguiar, Botelho, Lago, MaÇãs, & Sampaio, 2012; Filipe M. Clemente, Couceiro, Martins, & Mendes, 2012); however there has been published research with handball (Corvino, Tessitore, Minganti, & Sibila, 2014), basketball (Klusemann, Pyne, Foster, & Drinkwater, 2012) and different rugby codes (Tim J. Gabbett, Jenkins, & Abernethy, 2012; Kennett, Kempton, & Coutts, 2012). Small-sided games are popular with coaches as they are deemed to be a useful drill for concurrently training physical, technical and tactical qualities. Several authors have claimed that they are able to replicate the physiological, movement as well as technical and tactical demands of match-play with the appropriate design (S. V. Hill-Haas et al., 2011). However, their benefits have mainly been shown from a physical conditioning perspective. The major advantage of using SSGs for conditioning compared to running is the widespread belief that they lead to enhanced levels of motivation in the players and have a greater transfer to sport/match-specific fitness (Little, 2009; Stone & Kilding, 2009). For instance, SSGs were confirmed to be as effective as high-intensity running intervals (4 × 1000 m) in producing elevated heart rates (90% HRmax) and blood lactate concentrations in order to be used as a form of sport-specific endurance training (M. Buchheit et al., 2009; Dellal et al., 2008; Hoff, Wisløff, Engen, Kemi, & Helgerud, 2002; Little & Williams, 2006; Reilly, 2005). Small-sided games have also been shown to be effective in producing significant improvements in players' aerobic fitness levels when used in training interventions (Impellizzeri et al., 2006). Some recent studies have also investigated the acute effects of SSGs on anaerobic fitness including speed endurance (Ade, Harley, & Bradley,

2014) and agility (Davies, Young, Farrow, & Bahnert, 2013) highlighting that the agility demands of SSGs could be affected by changing player density, player number or adding a tag rule to the games to encourage evasive manoeuvres (Davies et al., 2013). Additionally, SSGs could be used to overload the anaerobic system through repeated accelerations (Ade et al., 2014).

In recent years the validity and reliability of wearable technology such as GPS (R. J. Johnston, Watsford, Kelly, Pine, & Spurrs, 2014) has improved to the point that they are regularly used to monitor the time-motion demands of different SSGs. Coaches are now able to monitor the movement demands of training sessions and games in order to create relevant conditioning drills (S. V. Hill-Haas et al., 2011). Practitioners have been interested in several different metrics such as total distance covered, distance covered within different velocity bands, number of sprints, peak velocity, accelerations as well as decelerations (Castellano, Casamichana, & Dellal, 2013; Hodgson, Akenhead, & Thomas, 2014). Researchers have shown that the highest work-rates are often found in SSGs with smaller numbers or possession games (Castellano et al., 2013; Mallo & Navarro, 2008; A. L. Owen, Wong, Paul, & Dellal, 2014). In contrast, the peak power outputs such as sprints, accelerations and decelerations are only produced with larger numbers and in bigger playing areas (Gaudino, Alberti, & Iaia, 2014; A. L. Owen et al., 2014). Additionally, it has been shown that SSGs do not replicate the specific high-intensity running and sprint demands that players encounter in matches (David Casamichana, Castellano, & Castagna, 2012; Tim J. Gabbett & Mulvey, 2008). This is most likely due to the fact that SSGs are typically played in smaller areas and players therefore lack the absolute space to reach peak running velocities. The practitioner needs to be aware of this in order to ensure that players are being conditioned adequately for match demands.

Importantly, practitioners can manipulate many different variables in the planning of SSGs in order to obtain the desired playing intensity. Some common variations include the player number, the duration and number of bouts, the rules and format of the SSG or the training regimen (Brandes, Heitmann, & Müller, 2012; David Casamichana, Castellano, & Dellal, 2013; Fanchini et al., 2011; S. V. Hill-Haas, Rowsell, Dawson, & Coutts, 2009). One of the most common variables to be manipulated in team sport studies is the actual SSG playing area (David Casamichana & Castellano, 2010; Rampinini et al., 2007). Typically, the adopted playing area appears to have been chosen arbitrarily. To our knowledge, no SSG study to date has provided justification for choosing specific playing areas beyond replicating previous authors' work. Recently, some authors have proposed the need to analyse players' physiological, movement and technical responses during SSGs using realistic playing areas (Fradua et al., 2013). One recommendation is to extrapolate the pitch area (m^2) and length to width ratio from official soccer match analyses when designing SSGs. In addition, the playing areas should include a goal-keeper area to replicate the demands of official matches for all playing positions (Fradua et al., 2013; Zubillaga et al., 2013). As a final point, considering the recent interest in quantifying technical and tactical performance during SSGs (David Casamichana & Castellano, 2010; Folgado, Lemmink, Frencken, & Sampaio, 2014; J. E. Sampaio, Lago, Gonçalves, Maçãs, & Leite, 2014), it would be logical to ensure that playing conditions (such as the amount of space to play in) are matched to those encountered during official competition. Currently, to our knowledge, no study has followed up on these recommendations by analysing players' acute physical responses when SSGs are played in more representative areas.

Beyond the predominant focus on player physical outputs during SSGs to date, the technical demands of SSGs have also been quantified, most often by basic frequency counts (David Casamichana & Castellano, 2010; Katis & Kellis, 2009; Kelly & Drust, 2009). It has been shown that smaller player numbers typically result in a greater frequency of individual involvements in the game (Hodgson et al., 2014; Adam L. Owen, Wong, McKenna, & Dellal, 2011). Some researchers have sought to provide more information to the practitioner by assessing the efficiency (% success ratio) of various individual technical actions (Dellal, Hill-Haas, Lago-Penas, & Chamari, 2011; Dellal, Lago-Penas, Wong, & Chamari, 2011; Tim J. Gabbett, Jenkins, et al., 2012). However there is still a need to develop the technical analyses of SSGs further should they be used as a standard training drill to develop players' skill levels. It would be useful to be able to quantify changes in technical performance over a certain period of time or following a given SSG training intervention. Currently there appears to be no published training studies that have monitored changes in technical performance following an SSG intervention. There is a need to advance the quantification of technical outputs in SSGs beyond simple frequency counts which might be a misleading representation of a player's technical contribution. For instance, the effectiveness of an individual's possessions (or 'involvements') in the game could be measured given it is possible for a player to be 100% successful with the resulting passes from their possessions whilst at the same time being ineffective with each one. The design of different scales or scoring methods for analysing the effectiveness of each player's possessions would be useful to address this weakness in meaningfully quantifying technical outputs during SSG.

Finally, the majority of SSG studies to date have focused on male team sport players (S. V. Hill-Haas et al., 2011). Surprisingly, there is currently very little known from SSGs with female soccer players from the one study that reported the physical outputs of senior players (Tim J. Gabbett & Mulvey, 2008) despite several studies reporting the official demands of female match play (Bradley, Dellal, Mohr, Castellano, & Wilkie, 2014; Martínez-Lagunas, Niessen, & Hartmann, 2014). The only SSG study to date was implemented with professional female soccer players and carried out before the recent improvements in portable GPS units. Results showed that 3v3 and 5v5 SSGs were unable to replicate official match high-speed running demands (Tim J. Gabbett & Mulvey, 2008). This type of study should be repeated with female players of all ages and abilities using modern GPS technology. In terms of official match performance, it appears that elite female players typically cover significantly less ($p < 0.01$) total distance (10754 m vs. 11142 m), less distance > 18 km/h (777 m vs. 1184 m) and have a lower passing accuracy (71.5 % vs. 79.4 %) relative to their male counterparts (Bradley et al., 2014). Whether equivalent gender differences are evident during SSGs is unknown and research into the physical and technical performance of female athletes of different ages and playing levels within training sessions and SSGs is required as this would enable coaches to adjust training sessions to the needs of the female player across the age range.

In summary, there is a lack of SSG studies conducted with female soccer players of all ages and abilities. Additionally, there still exists some uncertainty as to the optimal playing areas to be used in SSGs. Most studies to date appear to have chosen the pitch areas in order to provide a physical overload. There needs to be a greater emphasis placed on the integration of the physical as well as technical outputs and whether improvements in SSGs can eventually be translated to match performance. Therefore the aims of this thesis were to: 1) quantify the physiological, time-motion and technical outputs of young developing female soccer players during different SSGs formats; and 2) to determine the effects of manipulating the length: width ratio of the playing area, as per the recommendations of Fradua et al. (2013) regarding realistic SSG pitches, on the physiological, time-motion and technical outputs of young developing female soccer players.

CHAPTER 2: LITERATURE REVIEW

Introduction

This literature review aims to provide the reader with a general overview of the use of small-sided games (SSGs) within team sports. As illustrated by S. V. Hill-Haas et al. (2011), SSGs have lately been used extensively within training sessions as a form of physical conditioning. The recent and ongoing advancements in wearable technology (heart rate monitors, GPS) have enabled sports scientists and coaches to accurately quantify the physical demands placed on the athletes participating in SSGs and no doubt cemented their popularity within training sessions. This review is presented in three parts, namely the physical, technical and tactical responses during SSGs. Each section is organised in the same manner with an initial summary of the acute response and influencing factors, followed by training intervention studies and finally some practical recommendations are made based on the existing literature. Part A considers the physiological response and time-motion demands of SSGs used by different team sports. SSGs initially gained popularity as a form of sport-specific aerobic conditioning as practitioners were able to monitor their athletes' internal response (heart rate, blood lactate) to the training drills. In recent years the development of GPS technology has also enabled running demands and movement responses to be collected. This has prompted scientists to question whether it is possible to replicate match running demands and condition players appropriately by using SSGs in training sessions. Part B considers the technical demands of SSGs. In part C the tactical aspects of SSGs are reviewed.

This review is definitely called for as there are still uncertainties around the use of SSGs within training sessions. There are widespread claims that SSGs could in fact be used as a form of "integrated" training in order to develop players physically, technically and tactically at the same time. These claims require further validation. In particular, the tactical performance during SSGs has only recently started to get attention with some researchers. Notwithstanding the physical demands, the current state of research into the technical and tactical aspects of SSGs has not been reviewed to our knowledge. This review should therefore expose current gaps in the literature and help provide some recommendations for future studies.

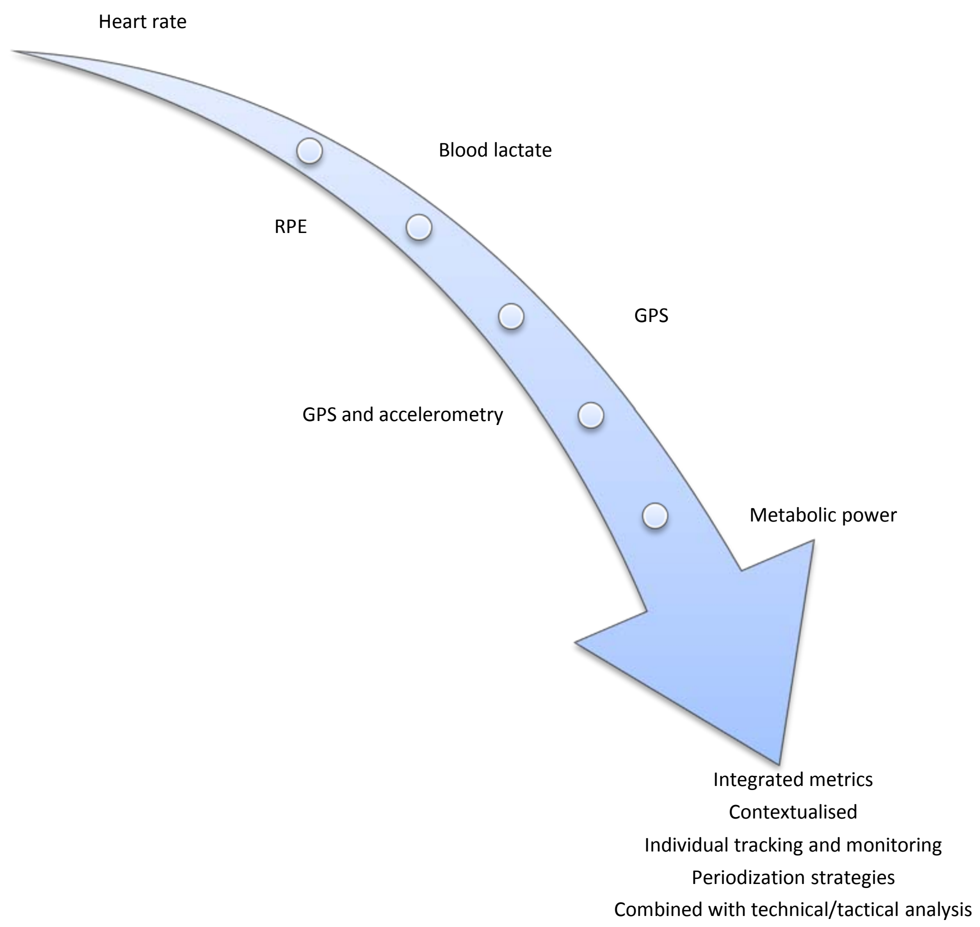

Figure 1: Monitoring of SSGs during training sessions

Part A: Physical aspects of small-sided games (SSG)

Acute response

Small sided games (SSGs) have been widely used as a form of sport specific aerobic conditioning (Little & Williams, 2006; Rampinini et al., 2007). Additionally they have been used to work on speed endurance and agility with players (Ade et al., 2014; Davies et al., 2013). Several studies have compared the demands of typical SSGs to full matches in soccer (David Casamichana et al., 2012; A. Dellal, A. Owen, et al., 2012; Tim J. Gabbett & Mulvey, 2008), field hockey (T. Gabbett, J., 2010), rugby league (Tim J. Gabbett, Jenkins, et al., 2012), basketball (Montgomery, Pyne, & Minahan, 2010) and Australian football (Boyd, Ball, & Aughey, 2013) with a particular focus on the physical demands. SSGs have been found to be equivalent or even exceed competition demands for several indicators of overall work-rate such as exertion index, distance covered.min^{-1}, work: rest ratio and player load (David Casamichana et al., 2012). The major limitation of small-sided games from a conditioning perspective appears to be an inability to overload specific physical qualities such high-intensity runs, sprints and accelerations (David Casamichana et al., 2012; Tim J. Gabbett, Jenkins, et al., 2012; Tim J. Gabbett & Mulvey, 2008). A further limitation with SSGs is the variation in physical outputs and physiological responses between players (Ade et al., 2014; Davies et al., 2013; Dellal et al., 2008). For instance, some authors have found inter-subject coefficient of variation to be almost double (CV=11.8% versus 5.9%) in the SSGs compared to intermittent running for the heart rate response (Dellal et al., 2008). Likewise, high amounts of between-player variation has been found for agility and repeated sprints (Ade et al., 2014; Davies et al., 2013). This has implications in team sports when seeking to optimize the fitness gains for all individuals within a playing squad. Therefore it is important for coaches and practitioners to be aware of all variables that could affect the acute physical response during SSGs and plan sessions accordingly.

Variables that influence the acute physical response to SSGs

The two most common variables to be manipulated in SSG studies to date have been the playing area (David Casamichana & Castellano, 2010; Hodgson et al., 2014; Rampinini et al., 2007; Tessitore, Meeusen, Piacentini, Demarie, & Capranica, 2006) and player number (S. Hill-Haas, Coutts, Rowsell, & Dawson, 2008; S. Hill-Haas, Rowsell, Coutts, & Dawson, 2008; S. V. Hill-Haas, Dawson, Coutts, & Rowsell, 2009; Stephen V. Hill-Haas et al., 2009; Köklü, Aşçi, Koçak, Alemdaroğlu, & Dündar, 2011; Adam L. Owen et al., 2011).

Playing area and player number

There have been four main strategies for manipulating the playing area as well as the number of players in the SSG: a) Non-systematic variation of playing area size with player number; b) Vary player number whilst maintaining a constant individual relative playing area (m^2 per player); c) Vary the individual relative playing area (m^2 per player) whilst maintaining a constant player number and d) Vary the number of players within a standard playing area.

Non-systematic variation of playing area size with player number

The majority of the earliest studies with SSGs in team sports were conducted with soccer (Katis & Kellis, 2009; Little, 2009; Little & Williams, 2006, 2007; Rampinini et al., 2007) during which the pitch size for SSGs was not initially selected in a systematic way. It appears dimensions were often chosen after pilot work in training had identified high playing intensities (Little & Williams, 2006) or sometimes according to the preference of the technical staff (A. L. Owen et al., 2014). Generally, the playing area and number of players were increased or decreased simultaneously (Little & Williams, 2006, 2007). Adopting this approach, most studies have reported similar findings revealing that the mean playing intensity (heart rate, %HRmax, blood lactate concentration, RPE) tended to be higher with a smaller number of players on each team (Adam L. Owen et al., 2011; Rampinini et al., 2007). For instance, a range of small-sided games from 2v2 (176±1.7 bpm or 90.8 %HRmax) up to 6v6 (175 bpm or 90.5 %HRmax) produced elevated heart rate responses with coefficients of variation of less than 3% in professional soccer players (Little & Williams, 2006). In addition, the greatest reproducibility of elevated physiological responses in a group of amateur soccer players was found when the coach provided constant encouragement (Rampinini et al., 2007). This suggests that certain SSGs (≤ 6v6) could be used for high-intensity aerobic training with teams regardless of the playing ability (amateur or elite). However, the coach may need to provide consistent vocal encouragement and/or adjust the playing area in order to ensure a consistently high physiological response throughout the entire group.

In order to monitor the workload placed on athletes during SSGs it is important to be able to quantify the external output (distances covered, sprints, peak running velocity and acceleration / deceleration frequency) alongside the internal physiological response (Halson, 2014). The combination of external output and the associated physiological response provides a clearer impression of physical performance (than either in isolation) and may even be used to detect fatigue (Halson, 2014). Time-motion analyses with professional soccer players have shown that smaller player numbers (4v4) in SSGs resulted in a significantly ($p < 0.01$) higher 'work-rate' (meters covered.min^{-1}) than larger (5v5 and 11v11) formats (A. L. Owen et al., 2014). However, the smaller sided games resulted in significantly less ($p < 0.01$) distance covered in high-intensity running and sprinting than larger formats (A. L. Owen et al., 2014). This may be explained by the lack of space for the individual players to accelerate to full speed but a need to work hard off the ball to find space and lose markers which would explain a high work-rate.

Some authors have reported the frequency and magnitude of the accelerations and decelerations in order to provide greater insight into the workload done in smaller SSGs (Paolo Gaudino et al., 2014). Indeed, smaller games (5v5) resulted in a greater frequency of moderate accelerations and decelerations as well as total number of changes in velocity compared to 7v7 and 10v10 (Paolo Gaudino et al., 2014). In contrast, games with greater players and space (10v10>7v7>5v5) resulted in the largest peak running velocities as well as high-magnitude accelerations and decelerations (Paolo Gaudino et al., 2014). Thus the physical loading placed on the player was different depending on the size of the game. The “mechanical load” placed on the athletes through a greater frequency of moderate changes in direction (particularly in smaller SSGs) was an additional stress to consider alongside the cardiovascular and high-speed running demands (Paolo Gaudino et al., 2014). In a further attempt to quantify player work-rate when movement is constrained by space, some studies have determined the metabolic power demands of different soccer small-sided games (Paolo Gaudino et al., 2014; P. Gaudino et al., 2014). In elite professional male players the energy demands of small-sided games (5v5, 7v7 and 10v10) were generally underestimated if coaches only considered absolute running speeds and not the energy cost of changes in running speed (accelerating or decelerating). In addition, this underestimation was greater for the smaller games (5v5>7v7>10v10) as well as central defenders (P. Gaudino et al., 2014).

A final variable worth monitoring is the peak sprint speed during training as it is an indicator of maximal effort and power output (Halson, 2014). Young team sport players were able to reach approximately 80-90% of their individual maximum sprint speed during official competition (Mendez-Villanueva & Buchheit, 2011; Mendez-Villanueva, Buchheit, Simpson, Peltola, & Bourdon, 2011; J. D. Vescovi, 2014). It was therefore recommended that team sport players should regularly take part in training drills that allow them to achieve near maximum sprint speeds (Mendez-Villanueva et al., 2011). The highest individual peak-running velocities ($km.h^{-1}$) achieved during SSGs has been reported in the largest games (≥9v9) (see table 2). However, the range of speeds reported in SSGs typically fall short of match peak-sprinting velocities from a variety of sports (see table 1). This has important implications for coaches and conditioning staff as players would probably need to play in larger format games during training sessions and complete supplementary speed training (resistance training, plyometric training, and sprints over 30-60 m distances) in order to develop this physical quality (Haugen, Tønnessen, Hisdal, & Seiler, 2014; Mendez-Villanueva et al., 2011).

Table 1: Peak velocities achieved during official competition for various team sports

Authors	Sport (Gender)	Playing level (age)	Peak match velocity (km.h^{-1})	Percentage of MSS (%)
Rampinini et al. (2007)	Soccer (male)	Elite professional	29.3-33.3	-
M Buchheit, Mendez-Villanueva, Simpson, and Bourdon (2010)	Soccer (male)	High performance academy (under 13-under 18)	22.3-28.3	85-90
Mendez-Villanueva et al. (2011)	Soccer (male)	High performance academy (under 18)	26.8-31	84.4-90.5
Vescovi (2012)	Soccer (female)	Elite professional	26.5 (individual peak) 21.8 (group average)	-
Tim J. Gabbett (2012)	Rugby league (male)	Elite professional	26.2-29.5	80.3-88
Higham, Pyne, Anson, and Eddy (2012)	Rugby sevens (male)	Elite professional	29.16 (domestic) 30.6 (international)	-
Suarez-Arrones, Nuñez, Portillo, and Mendez-Villanueva (2012)	Rugby sevens (female)	Elite professional	28.3 (individual peak) 22.9-23.2 (group average)	-
Luis Suarez-Arrones, Carlos Arenas, et al. (2014)	Rugby sevens (male)	Elite professional	27.4-28.2	-
Luis Suarez-Arrones, Javier Portillo, et al. (2014)	Rugby Union (female)	Elite professional	27.9 (individual peak) 22.9 (group average)	-
J. D. Vescovi (2014)	Field hockey (female)	U17 international U21 international	24.6 25	Peak: 90 Mean: 77-84
Brewer, Dawson, Heasman, Stewart, and Cormack (2010)	AFL (male)	Elite Sub-elite	27.8-29.6 27.8-30.3	-
Coutts, Quinn, Hocking, Castagna, and Rampinini (2010)	AFL (male)	Elite professional	28-29.1	-
Wisbey, Montgomery, Pyne, and Rattray (2010)	AFL (male)	Elite professional	29.7-30.3	-

MSS: Peak sprint speed as measured during a speed test

Table 2: Time-motion outputs in various SSGs

Authors	Sport	Player number	Individual relative playing area (m^2)	Peak Velocity ($km.h^{-1}$)	Playing bout duration (min)	Work-rate ($m.min^{-1}$)
S. V. Hill-Haas, B. T. Dawson, et al. (2009)	Soccer	2v2	150	-	24	107.2
		4v4				110.4
		6v6				107.9
Stephen V. Hill-Haas et al. (2009)	Soccer	2v2 I	147	-	4 × 6	108.1 (All C formats combined)
		2v2 C	147		24	
		4v4 I	150			109.2 (All I formats combined)
		4v4 C	150			
		6v6 I	151			
		6v6 C	151			
David Casamichana and Castellano (2010)	Soccer	5v5	272.8	23.1	8	125
			175	20.4	8	113.6
			73.6	18.05	8	87
S. V. Hill-Haas, Coutts, Dawson, and Rowsell (2010)	Soccer	3v4	148	-	24	100-112
		3v3 + F	148			
		5v6	149			
		5v5+F	149			
Dellal, Chamari, et al. (2011)	Soccer	2v2-P, 1T	75	-	2	163.2
		2v2-P, 2T				151.5
		2v2-P, FP				144.7
		3v3-P, 1T			3	187.3
		3v3-P, 2T				177
		3v3-P, FP				167.8
		4v4-P, 1T			4	191
		4v4-P, 2T				175.9
		4v4-P, FP				166.5
Dellal, Hill-Haas, et al. (2011)	Soccer	**Amateur**	75			
		2v2-P(1T, 2T, FP)		-	2	142.5

		3v3-P(1T, 2T, FP)		-	3	169.15
		4v4-P(1T, 2T, FP)		-	4	165.7
		Pro	75			
		2v2-P(1T, 2T, FP)		-	2	153.1
		3v3-P(1T, 2T, FP)		-	3	177.4
		4v4-P(1T, 2T, FP)		-	4	177.8
Dellal, Lago-Penas, et al. (2011)	Soccer	4v4-P, 1T, B1	75	-	4	208.9
		4v4-P, 1T, B2				198.4
		4v4-P, 1T, B3				189.9
		4v4-P, 1T, B4				167.2
		4v4-P, 2T, B1				177.9
		4v4-P, 2T, B2				172.3
		4v4-P, 2T, B3				166.9
		4v4-P, 2T, B4				151.2
		4v4-P, FP, B1				181.6
		4v4-P, FP, B2				169.8
		4v4-P, FP, B3				164.9
		4v4-P, FP, B4				149.4
Brandes et al. (2012)	Soccer	2v2	147		4	108
		3v3	147		5	116.6
		4v4	150		6	118.3
Brito, Krustrup, and Rebelo (2012)	Soccer	5v5 Sand	75	18.1	20	64.6
		5v5 Turf		22.7		93
		5v5 Asphalt		22		97.4
Dellal, Drust, and Lago-Penas (2012)	Soccer	2v2-P, 2T	75	-	2	152.1
		3v3-P, 2T		-	3	138.6
		4v4-P, 2T		-	4	167.1
A. Dellal, A. Owen, et al. (2012)	Soccer	4v4-P, 1T	75	-	4	191
		4v4-P, 2T		-		175.9
		4v4-P, FP		-		166.5
Köklü, Ersöz, Alemdaroğlu, Aşç, and Özkan (2012)	Soccer	4v4	108	-	4	125-128.8

Aguiar, Botelho, Gonçalves, and Sampaio (2013)	Soccer	2v2	150	-	6	99.8
		3v3				114.3
		4v4				113.69
		5v5				110
David Casamichana et al. (2013)	Soccer	5v5	210	-	16	115.9
					8	119.5
					4	122.7
Castellano et al. (2013)	Soccer	3v3-P, g, G	210	18.4	6	68.9
		5v5-P, g, G		20.3		79.4
		7v7-P, g, G		21.1		84.4
P. Gaudino et al. (2014)	Soccer	10v10	135	-	14	147.4-165.2
		7v7	98		8	97.1-111.2
		5v5	75		5	93.2-105.6
Harrison, Kilding, Gill, and Kinugasa (2014)	Soccer	6v6	142.9	-	16	90.5
		3v3	145.8	-		88.9
A. L. Owen et al. (2014)	Soccer	4v4	94	22.6	5	198.5
		5v5	184	20.6		102.6
		6v6	183	21.4		106
		7v7	174	23.2		110.5
		8v8	188	22.9		108.4
		9v9	218	24.1		124.8
		10v10	280	25.2		114.4
		11v11	336	24.7		121.9
Ade et al. (2014)	Soccer	1v1	243		0.5	171.8
		2v2	121.5		1	132.7
David Casamichana, Suarez-Arrones, Castellano, and Román-Quintana (2014)	Soccer	6v6 2T 1st period	245	18.2	12	113.4
		6v6 2T 2nd period		19.4	(2 ×6)	113.8
		6v6 FP 1st period		18.8		119.4
		6v6 FP 2nd period		17.4		107
Paolo Gaudino et al. (2014)	Soccer	5v5	75	20	4	100.5
		5v5-P	73	19	(normalised)	104.8
		7v7	98	23		103
		7v7-P	98	20		110.8

		10v10	135	26		110.2
		10v10-P	135	23		116.5
Hodgson et al. (2014)	Soccer	5v5	200	-	4	120.9
			120	-	4	121.3
			60	-	4	95.75
Köklü, Sert, Alemdaroğlu, and Arslan (2015)	Soccer	2v2 GK	100	-	2	117.6
		2v2 No GK				131
		3v3 GK			3	114.6
		3v3 No GK				132.25
		4v4 GK			4	121.7
		4v4 No GK				134.6
Tim J. Gabbett, Jenkins, and Abernethy (2010)	Rugby league	8v8 'on-side'	100		8	101
		8v8 'off-side'	100			127.1
Tim J. Gabbett, Abernethy, and Jenkins (2012)	Rugby league	8v8, junior, small	25	-	8	109.3
		8v8, junior, large	175			124.8
		8v8, senior, small	25			119.6
		8v8, senior, large	175			165.6
Tim J. Gabbett, Jenkins, et al. (2012)	Rugby league	7v7 wrestling	200	-	8	117.1
		7v7 no-wrestling	200	-		152.6
R. D. Johnston, Gabbett, and Jenkins (2015)	Rugby league	9v9	222.2	-	10	124-138
Kennett et al. (2012)	Rugby Union	4v4-S, L	96, 384	24.1	9	114
		6v6-S, L	64, 256	23.5		110
		8v8-S, L	48, 192	23.3		100
Vaz, Leite, João, Gonçalves, and Sampaio (2012)	Rugby Union	6v6 Nov.	200	-	12	98
		6v6 Exp.	200	-		102.2
Harrison, Gill, Kinugasa, and Kilding (2013)	Bucketball	3v3	145.8	-	16	88.4
		4v4	150	-		89.3
		6v6	142.9	-		89.2
Harrison et al. (2014)	Bucketball	6v6	142.9	-	16	90.5
		3v3	145.8	-		88.9
Corvino et al. (2014)	Hand	3v3	48	-	8	110.6

ball	75	-	122.5
	85.3	-	136.9

C: Continuous format; **I**: Intermittent format; **Exp**: Experienced group; **Nov**: Novice group; **1T**: 1 Touch; **2T**: 2 Touch; **FP**: Free play; **P**: Possession games; **g**: Small target goals; **G**: Regular goals + GKs

Vary player number and maintain a constant individual relative playing area (m^2)

Several authors have stated the need to standardise pitch size in order to isolate the effect of player number (Aguiar et al., 2012; S. V. Hill-Haas et al., 2011). The individual relative playing area (m^2) is usually defined as: playing area (length × width) / total number of outfield players (S. V. Hill-Haas et al., 2011). When the individual relative playing area is applied during SSGs, smaller player numbers tend to result in the highest physiological responses (Aguiar et al., 2013; Brandes et al., 2012; Dellal, Jannault, Lopez-Segovia, & Pialoux, 2011; S. V. Hill-Haas, B. T. Dawson, et al., 2009; Koklu, Albayrak, Keysan, Alemdaroglu, & Dellal, 2013). Unfortunately, few SSG studies have been reported in sports other than soccer. In "bucket ball" SSGs the highest heart rate and perceptual loads occurred in the 3v3 compared to 4v4 and 6v6 (Harrison et al., 2013).

Generally, it would appear that as the player number used in training drills decreases, the associated physiological demands increase accordingly. The opposite may be true for work-rate but especially sprinting and high-intensity running demands which increase as player numbers increase (Brandes et al., 2012). There were some contrasting results for work-rates during different small-sided games. Some found no significant difference in distance covered normalised for time (S. V. Hill-Haas, B. T. Dawson, et al., 2009), whereas others noted a lower absolute work-rate in 2v2 compared to larger playing numbers such as 3v3, 4v4, 5v5 and 6v6 (Aguiar et al., 2013; Brandes et al., 2012). Direct comparisons are difficult however as the players differed in age, ability level and the playing bout durations varied. High-intensity running and sprinting demands have been found to increase as player numbers increase with the same individual relative playing area (Brandes et al., 2012; Castellano et al., 2013; Harrison et al., 2013). This observation prompted some authors to claim that smaller numbers are better for aerobic conditioning whereas larger numbers are more appropriate for replicating the match high-intensity running demands (S. V. Hill-Haas, B. T. Dawson, et al., 2009). Castellano et al. (2013) reported peak running velocities during various soccer SSGs and noted a trend for increasing running velocities with larger player numbers. However, as described previously, neither SSG would seem able to condition the athletes appropriately for the peak match-running velocities that they are likely to encounter (see table 1).

Vary the relative individual playing area (small, medium and large) with the same number of players

The physiological, perceptual and movement demands generally increase in team sports as the relative playing area is increased (Atli, Köklü, Alemdaroğlu, & Koçak, 2013; David Casamichana & Castellano, 2010; Klusemann et al., 2012; Koklu et al., 2013; Rampinini et al., 2007). In contrast, there was no significant effect of playing area on heart-rate response in elite junior rugby league (Foster, Twist, Lamb, & Nicholas, 2010), semi-professional rugby union (Kennett et al., 2012) and amateur handball players (Corvino et al., 2014). In the direct comparison of two standard pitch sizes (large and small), the highest RPE (15.8 vs. 13.7), blood lactate response (8.2 vs. 5.7 $mmol.l^{-1}$), peak speed (25.8 vs. 21.3 $km.h^{-1}$), work rate (121 $m.min^{-1}$ vs. 94 $m.min^{-1}$) and high-speed running distance (316 vs. 88 m) were all reported in the larger playing area (Kennett et al., 2012). However, there was no significant difference in mean heart rate or time spent above 85%HRmax. The authors attributed this to high inter-player variability in heart rate response and suggested that individual monitoring during training is essential in order to guarantee that all individuals are exercising at the desired intensity (Kennett et al., 2012).

In young soccer players, a large pitch area resulted in greater physical outputs than medium and small areas for work-rate (125 vs. 113.6 vs. 87 $m.min^{-1}$), maximum speed (23.1 vs. 20.4 vs. 18.05 $km.h^{-1}$), sprint frequency (5.8 vs. 3 vs. 0.8), high-intensity running distance (74.2 vs. 28.5 vs. 4.9 m) and work-to-rest ratios (1.7 vs. 1.3 vs. 0.7) respectively (David Casamichana & Castellano, 2010). David Casamichana and Castellano (2010) used the concept of effective playing time, defined as the amount of time that the ball was in play during the game, to provide a reason for the differences in physical outputs. The smaller pitch had a significantly shorter effective playing time than the large and medium pitches which may have been caused by a lack of the necessary technical level to play with high-intensity in the smaller space and subsequently disrupted the flow of the games.

Vary player number within standard playing area

In some sports, a fixed playing area is utilised given the convenience or constraints of the playing and training environment. For example, a fixed playing area is common in basketball, as training drills are typically carried out on a full-court or half-court using the actual court dimensions (Castagna, Impellizzeri, Chaouachi, Ben Abdelkrim, & Manzi, 2011; Anne Delextrat & Kraiem, 2013). On a full court (28 × 15 m) 2v2 games resulted in greater VO_2, mean HR, blood lactate concentration and RPE responses than 3v3 and 5v5 games (Castagna et al., 2011). Similarly, 2v2 games resulted in higher HR responses (range: 90.7-88.2%HRmax) than 3v3 games (range: 87.6-82.2%HRmax) when played on a half-court (Anne Delextrat & Kraiem, 2013). In fact, in all team sports, the general finding has been that the intensity of the SSG increases as the number of players decreases (da Silva et al., 2011; Kennett et al., 2012). This was presumably due to the requirement of the players to have a greater involvement in the game coupled with a larger relative space to move in.

Time-motion variables also indicate a higher playing intensity with fewer players within the playing area. Using semi-professional male rugby union players, a decrease in player number (8v8→4v4) resulted in an increase in work-rate (12%), high-speed running distance (44%) and number of sprints (52%) (Kennett et al., 2012). Practitioners should note however that responses were individual-specific with coefficients of variation ranging from 13.6-16% (work-rate), 65-75% (high-speed running distance) and as high as 114-128% (sprint frequency). Clearly, not every player within the squad will be exposed to the same external work-load. This has obvious implications if the coach intends to use SSGs for conditioning purposes. Finally, these results should be interpreted with caution as they were collected with 1-HZ GPS units which have been shown to have poor reliability (Coutts & Duffield, 2010).

Bout duration, training regimen and pacing strategy

The duration of the majority of SSGs reported in the literature were 6-24 minutes (see table 3). Typically the games were played in an intermittent format over several shorter bouts < 8 minutes, however occasionally they were played in a continuous format of 12-24 minutes (S. Hill-Haas, Coutts, et al., 2008; S. Hill-Haas, Rowsell, et al., 2008). The optimum duration and training regimes for SSGs have yet to be determined. The only study to directly compare bout duration in soccer players recommended 4 minutes for 3v3 games (Fanchini et al., 2011). However the authors did mention that the differences in playing intensity (%HR and RPE) and technical performance between 2, 4 and 6-min bouts were minimal suggesting that the practitioner could probably prescribe a variety of different bout durations with minimal differences in the players' response.

Several studies have sought to establish the optimum training regime by directly comparing continuous or intermittent formats of SSGs (see table 3). A continuous format of 24-min resulted in a higher mean heart-rate and RPE load than an intermittent format with repeated bouts of 6-min (Stephen V. Hill-Haas et al., 2009). Similarly, when looking at a variety of bout lengths within rugby league SSGs, the authors reported a trend for lower cardiovascular responses and perceived exertion with shorter bouts (Sampson, Fullagar, & Gabbett, 2015). However, the training response may depend on the sport and the individual characteristics of the athletes as several studies have reported no differences between the two training regimes (David Casamichana et al., 2013; Klusemann et al., 2012; Köklü, 2012). In addition, it may be the case that variables such as playing area and player number are more important factors than the actual training regime when looking at physiological responses with team sport players (Klusemann et al., 2012). One practical strategy would be for coaches to decide on their chosen strategy by monitoring the amount of time spent > 90% HRmax for the duration of the SSG (David Casamichana et al., 2013; Stephen V. Hill-Haas et al., 2009). A recent recommendation for team sport athletes is to choose an exercise that enables them to spend at least 5-7 minutes > 90% VO_{2max} per session if the training goal is high intensity aerobic conditioning (Martin Buchheit & Laursen, 2013). Accordingly, previous authors have successfully used time spent > 90-95% HRmax as a training reference during SSGs (Hoff et al., 2002; Impellizzeri et al., 2006).

Some authors have suggested that the intermittent SSG format with shorter bout duration may be superior for exposing players to high-intensity running as well as repeated sprints and accelerations as they occur with greater frequency (Stephen V. Hill-Haas et al., 2009; Sampson et al., 2015) and lower variability (S. Hill-Haas, Coutts, et al., 2008) when compared to continuous formats. This could be due to the partial phosphocreatine and neuromuscular recovery coupled with enhanced neural drive made possible by the lower work: rest ratios and longer relative recovery periods (Sampson et al., 2015). In summary, the choice of regime may depend on the physical goal of the training session. Coaches are therefore advised to monitor the physiological and time-motion effects of different training regimes with their athletes.

Table 3: A comparison of different training regimes used for SSGs

Authors	**Sport**	**Gender (age)**	**Playing level**	**Fitness**	**Training Regimen**	**Significant Differences**
S. Hill-Haas, Coutts, et al. (2008)	S	Male (15.6-17.9 years)	South Australian Sports Institute	Not reported	24’ (C) 4×6’ + 1.5’ passive rest (I)	TE% for HR < 5% all games TE% RPE > in (C) than (I) for 2v2 and 6v6 but not 4v4 TE% TD in (I) > than (C) TE% HIR in (C) > than (I) TE% HIRD range: 25.7-56%
S. Hill-Haas, Rowsell, et al. (2008)	S	Male (16.3 ± 0.6 years)	Amateur top level u-19 domestic	Not reported	24’ (C) 4×6’ + 1.5’ passive rest (I)	Within and between session TE% HIRD (range): 26-51%
Stephen V. Hill-Haas et al. (2009)	S	Male (16.2 ± 0.2 years)	Amateur top level u-19 domestic	V_{O2}max: 54.8 ± 0.7 ml/kg/min	24’ (C) 4×6’ + 1.5’ passive rest (I)	SSG (I) = 26% ↑ SD / 33.3% ↑ S# / 55% ↑ ST SSG (C) = 3.5% ↑ %HRmean / 6% ↑ RPE
Köklü (2012)	S	Male (16.6 ± 0.5 years)	Elite youth academy	Not reported	6’ (C)/ 3×2’ (I) 9’ (C)/ 3×3’ (I) 12’ (C)/3×4’ (I)	No sig. diff (C) and (I). 3v3 (I) %HRmean: 3.84% > 2v2 (I) and 2.1% > 4v4 (I). 3v3 (C) %HRmean: 2.7% > 2v2 (C) and 2.1% > 4v4 (C)
David Casamichana et al. (2013)	S				16’ (C) 2×8’ (I) 4×2’ (I)	No sig. diff for %HRmean, time > 90% HRmax, TD, HSD and PL
Klusemann et al. (2012)	BB	Male (18.2 ± 0.3 years) Female (17.4 ± 0.7 years)	Elite academy (Australian Institute of Sport)	Not reported	4×2.5’ (I) 2×5’ (I)	Trivial, small and moderate diff between R

Sampson et al. (2015)	RL	24’ (C) 2×12’ 3×8’ 4×6’ 6×4’ 8×3’ 12×2’ 24×1’	No diff for TD ↓ GD = ↑ MS, HS and VHS + Acc ↑ rate of decline for 24×1’ Different PS for different GD

S: Soccer; **BB:** Basketball; **RL:** Rugby league; **C:** Continuous format; **I:** Intermittent; **GD:** Game Duration; **R:** Work Regimes **HR:** Heart Rate; **TE%:** Typical Error; **TD:** Total Distance **HIR:** High Intensity Running; **HIRD**: High Intensity Running Distance; **MS:** Moderate Speed; **HS:** High Speed; **HSD:** High Speed Distance **VHS:** Very High Speed **SD:** Sprint Distance; **S#:** Sprint Number; **ST:** Time sprinting; **Acc:** Accelerations; **PS:** Pacing Strategy

Researchers have examined physical responses across repeated bouts of SSGs in order to establish whether there are any changes in performance (da Silva et al., 2011; Tim J. Gabbett, Jenkins, et al., 2012; Katis & Kellis, 2009; Kelly & Drust, 2009). The physiological responses (heart rate, blood lactate, RPE) tend to increase throughout the playing bouts. In particular the responses in the 1st bout tend to be significantly lower than the subsequent ones (da Silva et al., 2011; Kelly & Drust, 2009; Köklü et al., 2011). This has important implications for coaches and scientists to control the intensity at the start of SSGs or during the preceding warm-up. To our knowledge, there were no studies that have specifically reported the effect of different types of warm-up on the subsequent playing intensity during the SSGs.

In contrast, the time-motion variables such as work-rate, high-intensity running and frequency of sprints tend to decrease across repeated bouts of SSG (A. Dellal, B. Drust, et al., 2012; Dellal, Lago-Penas, et al., 2011; Tim J. Gabbett, Jenkins, et al., 2012). The magnitude of the change in physical outputs is most likely related to the playing intensity. For instance, the biggest changes in physiological responses and time-motion outputs have been found when soccer SSGs were played with limited touches allowed or smaller numbers (2v2 vs. 3v3 vs. 4v4) on each side (A. Dellal, B. Drust, et al., 2012; Dellal, Jannault, et al., 2011). Presumably, this was due to the players having greater involvement with the ball and being required to move with a higher intensity in order to quickly support teammates. Presently it is difficult to conclude whether the differences seen across the playing bouts are caused by the gradual accumulation of fatigue in the players, the time needed to enter into the game or possible evidence of a pacing strategy. With regards to pacing, some authors manipulated the work: rest ratios of SSGs in order to observe pacing strategies with rugby league players (Tim J Gabbett, Walker, & Walker, 2015; Sampson et al., 2015). Three different pacing strategies were identified within the games of different bout durations, namely “all-out”, “constant pace” and “variable/end-spurt” (Sampson et al., 2015). Additionally some authors reported a lower pacing strategy on average when the players were given specific information on bout duration (Tim J Gabbett et al., 2015). However, the adopted pacing strategy varied amongst the players so the specific information given to the athlete may need to be individualised throughout a team. The transfer of pacing strategy from training sessions to official match performance is as yet unclear so this variable warrants further investigation (Waldron & Highton, 2014).

Game rules

Several studies have creatively manipulated the rules of SSGs and reported the effect on playing intensity (table 4). For example, in rugby league, adaptations to games included the use of intermittent wrestling and allowance of off-side passes (Tim J. Gabbett et al., 2010; Tim J. Gabbett, Jenkins, et al., 2012). Off-side rugby league games resulted in greater HR responses as well as high-intensity running demands (Tim J. Gabbett et al., 2010). In contrast, intermittent wrestling SSGs produced a greater amount of maximal-acceleration efforts via player contacts (Tim J. Gabbett, Jenkins, et al., 2012; R. J. Johnston et al., 2014). In contact games, the work-rate was 18% lower (ES = 2.45 ± 1.09) than non-contact games. Thus both types of games were useful for conditioning different physical qualities.

In soccer, the most popular modifications to standard SSGs include possession games, presence of target or support players outside of the playing area, small target goals instead of regular sized goals and end ‘stop-ball’ zones (Castellano et al., 2013; Dellal, Chamari, et al., 2011; Dellal, Lago-Penas, et al., 2011; Halouani, Chtourou, Dellal, Chaouachi, & Chamari, 2014; Köklü et al., 2015; Mallo & Navarro, 2008). In addition some authors have also used artificial rules related to a team's chances of scoring in order to increase playing intensity (S. V. Hill-Haas et al., 2010). Typically, the presence of goalkeepers in SSGs lowers the physiological and running demands (Castellano et al., 2013; Köklü et al., 2015; Mallo & Navarro, 2008). Castellano et al. (2013) reported that possession games produced the highest heart rate, work-rate, player load and work: rest ratio responses compared to regular games with GKs. In contrast, the highest peak-running speeds were recorded in games with small target goals (Castellano et al., 2013). The authors did note however that the number of players per side (3 vs. 5 vs. 7), rather than game format, may have been the variable that had the biggest effect on playing intensity (Castellano et al., 2013).

Studies with different sports have used diverse rules and conditions within the games in order to increase the playing intensity. These include rules such as man-to-man marking (Ngo et al., 2012), restrictions on the number of touches allowed (Dellal, Chamari, et al., 2011; Dellal, Lago-Penas, et al., 2011), fewer number of plays per possession (Tim J. Gabbett, Jenkins, et al., 2012) as well as shortened shot-clocks (Klusemann et al., 2012). In soccer possession drills, applying a 1-touch restriction to elite professional players resulted in greater perceptual, blood lactate, work-rate and high-intensity running demands than when players could play freely (Dellal, Chamari, et al., 2011; Dellal, Lago-Penas, et al., 2011). Similarly, the heart rate and perceptual responses were higher when players had to adopt a man-marking strategy (Ngo et al., 2012). There was also less variation and greater reproducibility of the physiological responses when using man-marking, making this modification useful if the coach wishes to apply a consistent training stimulus to a squad of players (Ngo et al., 2012). Finally, findings show that some artificial rules placed on the game can help to maintain a high playing intensity. A typical example from soccer SSGs would be that all players must be in the attacking half of the playing area for a goal to count (da Silva et al., 2011; S. V. Hill-Haas et al., 2010).

Despite the observed increases in physiological responses and physical outputs resulting from SSG format and rule modification, a challenge for practitioners to consider is whether the adapted SSGs are realistic and specific enough to the actual competitive scenario for their athletes? Clearly, there is a trade-off between providing a sport-specific conditioning effect and being too far removed from the playing conditions encountered during matches (off-side games in rugby, non-directional possession games and artificial rules in soccer). For instance, in ruby league, the on-side games were found to place a greater cognitive load on players (Tim J. Gabbett et al., 2010) suggesting that this game format provided a greater learning opportunity to the players despite resulting in a lower playing intensity than the off-side games. It is currently unknown whether it is possible to provide an adequate conditioning stimulus to the team sport player whilst maintaining realistic playing areas, formats, rules and conditions although some studies in soccer have recently advocated the use of realistic pitch sizes and goalkeeper areas based on official match analyses (Fradua et al., 2013). Future studies using similar recommendations for playing area dimensions are called for in all team sports.

Table 4: Summary of modifications and rules used in SSGs

Authors	Sport	Gender (age)	Playing level	Fitness	Game modification	Main findings
Mallo and Navarro (2008)	S	Male (18.4 ± 0.6 years)	Elite U-19	Not reported	P vs. P + 2S vs. G	$\%HR_{mean}$: P and P + 2S = 3.4% > G ($p < 0.05$) WR: P = 17.1% > G ($p > 0.01$) P + 2S = 17.4% > G ($p > 0.01$)
Dellal, Chamari, et al. (2011)	S	Male (27.4 ± 1.5 years)	Elite international team	vVO_{2max}: 17.4 ± 0.8 km/h	P + 4S 1T vs. 2T vs. FP 2v2, 3v3 and 4v4	2v2 WR in 1T = 7.73% > 2T and 12.76% > FP ($p < 0.001$) HIR in 1T = 21.77% > 2T and 34.47% > FP ($p < 0.001$) 3v3 WR in 1T = 5.78% > 2T ($p \leq 0.05$) and 11.6% > FP ($p < 0.001$) WR in 2T = 5.5% > FP ($p \leq 0.05$) HIR in 1T = 10.4% > 2T and 23.86% > FP ($p < 0.001$) HIR in 2T = 12.19% > FP ($p < 0.01$) 4v4 $\%HR_{mean}$ in 1T = 3.42% > FP WR in 1T = 8.62% > 2T and 14.78% > FP ($p < 0.001$) WR in 2T = 5.67% > FP ($p \leq 0.05$) HIR in 1T = 13.68% > 2T and 32.36% > FP ($p < 0.001$) HIR in 2T = 16.43% > FP ($p < 0.001$)
Dellal, Lago-Penas, et al. (2011)	S	Male (27.4 ± 1.5 years)	Elite international team	Not reported	1T vs. 2T vs. FP B1-B4	$\%HR_{mean}$: B4 = 6.35% > B1 in 1T, 7.55% > B1 in 2T and 4.96% > B1 in FP ($p < 0.05$) WR: B4 = 24.97% < B1 in 1T, 17.68% < B1 in 2T and 21.54% < B1 in FP ($P < 0.001$)

						1T = 14.29% > 2T and 14.76% > FP (p < 0.001)
Abrantes, Nunes, MaÇãs, Leite, and Sampaio (2012)	S	Male (15.75 ± 0.45 years)	High level	Not reported	GAME vs. OFF vs. DEF 3v3 and 4v4	RPE: 3v3 = 3.75% > 4v4 (p = 0.028, ES = 1.42) GAME = 6.9% > OFF (p = 0.023, ES = 2.14) GAME = 6.25% > DEF (p = 0.023, ES = 2.36) Time ≥ 90% HRmax: 3v3 = 83.3% > 4v4 (p = 0.011) GAME = 18.1% > OFF (p = 0.000) GAME = 650% > DEF (p = 0.000)
Ngo et al. (2012)	S	Male (16.2 ± 0.7 years)	Recreational / school team	Not reported	MM vs. NMM P vs. g	%HRreserve MM = 6.34% > NMM with g and 5.78% > NMM with P (p < 0.05) RPE: MM = 18.33% > NMM with g (P < 0.05)
Castellano et al. (2013)	S	Male (21.3 ± 2.3 years)	Semi-professional	YYIRT1: 2384.6 ± 348.5 m	P vs. g vs. G	%HRmean SSG-P = 4.83% > SSG-g and 2.72% > SSG-G WR SSG-P = 17.2% > SSG-g and 13.94% > SSG-G MaxS SSG-P = 19.5 ± 2.5 $km.h^{-1}$ SSG-g = 21.1 ± 2.8 $km.h^{-1}$ SSG-G = 20.1 ± 2.3 $km.h^{-1}$
Köklü et al. (2015)	S	Male (16.5 ± 1.5 years)	Elite Academy	YYIRT1: 1735 ± 336.1 m	'With GK' and 'without GK' 2v2, 3v3 and 4v4	2v2 'Without' → %HRmean 2.32%↑; WR 11.37% ↑ 3v3 'Without' →%HRmean 2.53% ↑; WR 15.3% ↑ 4v4 'Without' → %HRmean 1.57% ↑; WR 10.58% ↑

Tim J. Gabbett et al. (2010)	RL	Male (17.3 ± 0.9 years)	Elite development squad (National Rugby League)	Not reported	On-side vs. off-side	'Off-side' = 25.84% ↑ WR; 30.25% ↑ moderate Acc; 96.1% ↑ HIRD; 78.6% ↑ RHIB
Tim J. Gabbett, Jenkins, et al. (2012)	RL	Male (21.6 ± 0.5 years)	Elite (National Rugby League)	Not reported	Wrestling	W/o wrestling = 30.3% ↑ WR; 38.36% ↑ HIR and 57.5% ↑ VHIR. With wrestling = 84.6% ↑ maximal Acc; 90.5% ↑ RHIB
R. D. Johnston, Gabbett, Seibold, and Jenkins (2014)	RL	Male (19.1 ± 0.8 years)	Elite junior (National Rugby League)	Not reported	Contact	Non-contact = 18% ↑ WR (ES = 2.45); 21% ↑ HIRD (ES = 0.78)

S: Soccer**; RL:** Rugby league; **B:** Bouts; **WR:** Work-rate; **P:** Possession game; **P + S:** Possession with outside support players; **G:** Regular game with GKs; **g:** game with small target goals; **OFF:** Offence Only game; **DEF:** Defence Only **1T:** one touch; **2T:** two touches; **FP:** Free Play; **MM:** Man Marking; **NMM:** Non Man Marking **HIR:** High Intensity Running; **HIRD:** High intensity Running Distance, **VHIR:** Very High Intensity Running; **MaxS:** Maximum Speed; **Acc:** Accelerations; **RHIB:** Repeated High Intensity Bouts

Training interventions

While acute observational and comparison studies provide a useful insight in to the demands and variability of various measures during SSGs, only longer term training studies can elucidate the true effectiveness of various formats of SSGs to improve physical, technical and tactical abilities in team sport players. Indeed, SSG training studies have been reported for several different team sports lasting between 4 and 12 weeks (see table 5). SSGs have often been used as a replacement for traditional conditioning with a specific objective to improve aerobic fitness and intermittent running performance (Charalampos, Zisis, Asterios, & Nikolaos, 2013; Dellal et al., 2008; Dellal, Varliette, Owen, Chirico, & Pialoux, 2012; Impellizzeri et al., 2006). However, some recent studies have also looked at the potential of SSGs to improve anaerobic qualities such as sprint speed, repeated-sprint ability and agility (Chaouachi et al., 2014; S. V. Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Adam L. Owen, Wong, Paul, & Dellal, 2012; Seitz, Rivière, de Villarreal, & Haff, 2014) as well as technical performance (A. Delextrat & Martinez, 2014; Tim J. Gabbett, 2008).

Table 5: Summary of SSG interventions

Authors	n	Sport	Playing level (age)	Fitness level	Study Design (Groups)	Outcome measures	Outcomes
Tim J. Gabbett (2006)	69	Rugby League	Sub elite Season 1 (22.3 ± 0.8 years) Season 2 (22.1 ± 0.9 years)	$V0_2$max (SSG = 46.6 ± 0.5 ml.kg.min^{-1}; GTG = 49.6 ± 0.7 ml.kg.min^{-1})	Single group longitudinal (SSG / GTG) 9 weeks	CMJ, 10 m, 20 m and 40 m sprint, Agility, $V0_2$max, team match performance	**GTG:** 10 m ↓ 2.7 % ($p < 0.05$) V_{O2} max ↑ 5.2 % ($p < 0.05$) **SSG:** 10 m ↓ 5.2 % ($p < 0.05$) 20 m ↓ 3.2 % ($p < 0.05$) 40 m ↓ 3.0 % ($p < 0.05$) V_{O2} max ↑ 4.7 % ($p < 0.05$)
Impellizzeri et al. (2006)	29	Soccer	Youth elite professional (17.2±0.8 years)	$V0_2$max (GTG = 55.6 ± 3.4 ml.kg.min^{-1}; SSG = 57.7 ± 4.2 ml.kg.min^{-1})	Parallel, 2 groups, longitudinal. Pre-, mid- and post-testing (SSG / GTG) 12 weeks	VO_2max, VO_2 @ Tlac, Vel @ Tlac, Ekblom test, match performance (TD, time in different velocity bands, time in HR zones)	**GTG** Pre-Mid: VO_2 max ↑ 7.37 %; VO_2 @ Tlac ↑ 7.98 %; Vel @ Tlac ↑ 3.57 %, Ekblom test ↓ 13.91 % Mid-Post: Ekblom test ↓ 2.48 % **SSG** Pre-Mid: VO_2 max ↑ 6.41 %; VO_2 @ Tlac ↑ 7.18 %; Vel @ Tlac ↑ 5.3 %, Ekblom test ↓ 14.94 % Mid-Post: Ekblom test ↓ 3.28 %

Tim J. Gabbett (2008)	25	Volleyball	Queensland Academy of Sport, male and female junior international (15.6±0.1 years)	$V0_2max$ (TECH = 43.8 ± 2.0 ml.kg.min^{-1}; SSG = 45.7 ± 2.0 ml.kg.min^{-1})	Parallel, 2 groups. Pre- and post-testing. (SSG / TECH) 12 weeks	Technique and accuracy (4 skills), body mass (kg), vertical jump (cm), spike jump (cm), 5m sprint (s), 10m sprint (s), Agility (s), overhead med. Ball throw (m), VO_2max (ml/kg/min)	**TECH:** Spike jump ↑ 6.6 % ($p < 0.05$) 5 m ↓ 5.1 % ($p < 0.05$) 10 m ↓ 3.6 % ($p < 0.05$) **SSG:** Vertical jump ↑ 12.8 % ($p < 0.05$) Spike jump ↑ 3 % ($p < 0.05$) 5 m ↓ 3.1 % ($p < 0.05$) 10 m ↓ 2.2 % ($p < 0.05$) Agility ↓ 10.4 % ($p < 0.05$) Overhead Med. Throw ↑ 7.1 % ($p < 0.05$) VO_2 max ↑ 6.9 % ($p < 0.05$)
M. Buchheit et al. (2009)	32	Handball	Highly trained adolescents, male and female (15.5±0.9 years)	V_{IFT} (SSG = 18.4 ± 1.5 km.h^{-1}; GTG = 17.9 ± 1.8 km.h^{-1})	Parallel, 2 groups. Pre-/post-testing (SSG / GTG) 10 weeks	CMJ (cm), 10 m sprint (s), RSA (s), V_{IFT} (km/h)	RSA_{best} ↓ 3.5 % ($p < 0.05$) RSA_{mean} ↓ 3.9 % ($p < 0.05$) V_{IFT} ↑ 6.3 % ($p < 0.05$) **No diff. GTG and SSG**
S. V. Hill-Haas, A. J. Coutts, et al. (2009)	19	Soccer	Australian Institute of Sport , males (14.6±0.9 years)	$V0_2max$ (GTG = 60.2 ± 4.6 ml.kg.min^{-1}; SSG = 59.3 ± 4.5 ml.kg.min^{-1})	Parallel, 2 groups. Pre-/post- testing (SSG / GTG) 7 weeks	VO_{2max} (ml/kg/min), treadmill time to exhaustion (s), multi-stage fitness test (m), Yo-Yo Intermittent recovery level 1 (m), RSA time (s), 5 and 20 m sprint time (s)	**SSG:** YYIRT1 distance ↑ 17% ($p = 0.004$) **GTG:** YYIRT1 distance ↑ 21.94% ($p = 0.004$)

Alexandre Dellal et al. (2012)	22	Soccer	Amateur male 5th division (26.3±4.7 years)	Not reported	Parallel, controlled study, 3 groups. Pre- and post-testing (SSG / GTG / CON) 6 weeks	Vameval test, 30-15 intermittent fitness test	**SSG:** $_{V}$Vameval ↑ 6.6 % (p = 0.02) V_{IFT} ↑ 5.1 % (p = 0.03) **GTG:** $_{V}$Vameval ↑ 5.1 % (p = 0.006) V_{IFT} ↑ 5.8 % (p = 0.005) **CON:** No change (p = 0.04)
Adam L. Owen et al. (2012)	15	Soccer	Elite male (24.5±3.45 years)	$V0_2max$ (54.88 ± 5.25 $ml.kg.min^{-1}$)	Single group pre-/post-testing (SSG) 4 weeks	Submaximal aerobic performance, RSA performance, skinfolds	10m ↓ 1.14 % (ES = 0.35) 20m ↓ 0.64 % (ES = 0.27) RSA_{total} ↓ 1.85 % (ES = 0.57) $RSA_{\%decrement}$ ↓ 39 % (ES = 0.75)
Chaouachi et al. (2014)	36	Soccer	Elite level youth males (14.2 ± 0.9 years)	Not reported	Parallel, controlled study, 3 groups. Pre- and post-testing (SSG / GTG / CON) 6 weeks	10 m, 15 m, 20 m, 30 m COD 15 m, Ball 15 m, 10-8-8-10, Z 20 m, RAT, RAT-ball, 5 J, ACMJ	**GTG:** 30m ↓ 4.16%; 20m ↓ 3.28%; 15m ↓ 7.69%; 10m ↓ 1.78%; COD ↓ 12.65%; Ball 15 m ↓ 5.98%; 10-8-8-10 ↓ 5.1%; Z 20 m ↓ 5.26%; RAT ↓ 3.77%; RAT-ball ↓ 5.12% **SSG:** 30m ↓ 1.57%; 20m ↓ 1.28%; 15m ↓ 2.11%; 10m ↓ 1.18%; COD ↓ 5.84%; Ball 15 m ↓

							10.04%; 10-8-8-10 ↓ 3.29%; Z 20 m ↓ 2.53%; RAT ↓ 5.09%; RAT-ball ↓ 8.16% **CON:** 30m ↓ 1.58%; 20m ↓ 1.6%; 15m ↓ 2.13%; 10m ↓ 0.58%; COD ↓ 5.74%; Ball 15 m ↓ 3.58%; 10-8-8-10 ↓ 1.79%; Z 20 m ↓ 2.65%; RAT ↓ 2.69%; RAT-ball ↓ 5.09% ($p < 0.01$)
A. Delextrat and Martinez (2014)	18	Basketball	Junior, regional level, males (U 17)	V_{IFT} (SSG = 17.2 ± 1.7 km.h^{-1}; GTG = 17.4 ± 0.7 km.h^{-1})	Parallel, 2 groups. Pre-/post- testing (SSG / GTG) 6 weeks	$V_{IFT,}$ RSA, defensive agility, control dribble test, upper body power, lower body power, shooting skill, passing skill	**GTG:** V_{IFT} ↑ 3.45% (p = 0.028); offensive agility ↓ 4.51% (p = 0.001) **SSG:** V_{IFT} ↑ 4% (p = 0.028); defensive agility ↓ 4.75% (p = 0.037); offensive agility ↓ 7.75% (p = 0.001)
Seitz et al. (2014)	10	Rugby League	Elite male (20.9±1.4 years)	V_{IFT} (19.35 ± 1.00 km.h^{-1})	Single group pre-/post-testing (SSG) 8 weeks	V_{IFT}, 10m, 20m, 40m, RSA	V_{IFT} ↑ 1.29 % (ES = 1.29) 10 m sprint ↓ 3.17 % (ES = 12.99) 20 m sprint ↓ 1.37 % (ES = 10.88) 40 m sprint ↓ 0.96 % (ES = 6.33)

							RSA_{mean} ↓ 2.11 % (ES = 6.48) RSA_{total} ↓ 2.11 % (ES = 0.81) $RSA_{\%decrement}$ ↓ 1.17 % (ES = 0.27)
Iacono, Eliakim, and Meckel (2015)	18	Handball	Elite male (25.6 ± 5 years)	YYIRT1 (SSG = 1364 ± 317 m; GTG = 1297.8 ± 300 m)	Parallel, 2 groups. Pre-/post- testing (SSG / GTG) 10 weeks	YYIRTL1, 10 m, 20 m, HAST, Bench press, CMJ, CMJarm	**GTG:** YYIRTL1 ↑ 23.37%; 10 m sprint ↓ 1.97%; 20 m sprint ↓ 1.81%; HAST ↓ 1.05%; Bench press ↑ 6.8%; CMJ ↑ 7.58%; CMJarms ↑ 6.46% **SSG:** YYIRTL1 ↑ 26.3%; 10 m sprint ↓ 4.05%; 20 m sprint ↓ 4.07%; HAST ↓ 2.14%; Bench press ↑ 12.57%; CMJ ↑ 10.96%; CMJarms ↑ 8.92% ($p \leq 0.05$)

SSG: Small sided games training; **GTG:** General/running based conditioning; **CON:** Control group; **YYIRTL1**: Yo-yo intermittent recovery test level 1

There have been two training studies reported with elite professional team sport players and which have provided evidence that conditioning programmes based solely on SSGs can help maintain various fitness markers during a season (Adam L. Owen et al., 2012; Seitz et al., 2014). Both rugby league and soccer players made significant improvements in shuttle running and repeated-sprint performance (table 5). The majority of training studies have used two experimental groups, comparing SSG-based conditioning sessions with generic fitness drills (GTG) such as high-intensity running intervals, multi-directional shuttle runs and repeated sprints (M. Buchheit et al., 2009; Charalampos et al., 2013; Tim J. Gabbett, 2006; S. V. Hill-Haas, A. J. Coutts, et al., 2009; Impellizzeri et al., 2006). The results have not found significant effects of training group on selected fitness variables, indicating similar improvements for SSG and GTG. For instance, improvements of 3.45-4% (A. Delextrat & Martinez, 2014) and 6.3% (M. Buchheit et al., 2009) in the V_{IFT}, 17-21.94% (S. V. Hill-Haas, A. J. Coutts, et al., 2009) and 23.37-26.3% (Iacono et al., 2015) in the yo-yo intermittent recovery test (YYIRT1) and 6.41-7.37% (Impellizzeri et al., 2006) or 6.9% (Tim J. Gabbett, 2008) in VO_2max have been reported in both GTG and SSG. A controlled study with amateur soccer players reported significant ($p < 0.05$) improvements in fitness scores within both SSG and GTG (Alexandre Dellal et al., 2012). The SSG and GTG improved their Vameval (6.6% and 5.1% respectively) and V_{IFT} scores (5.1% and 5.8% respectively) whereas the control group made no improvements ($p < 0.05$).

Chaouachi et al. (2014) specifically targeted different anaerobic qualities including short sprints, change of direction and reactive agility. Young elite soccer players made greater improvements in tests of reactive agility compared to generic conditioning (COD) and control groups following a 6-week training programme (Chaouachi et al., 2014). In contrast, the COD group displayed greater improvements in linear sprints, change of direction drills and jump tests (Chaouachi et al., 2014).

Impellizzeri et al. (2006) reported the mean HR response, total distance covered as well as time spent in different velocity bands of players during 3 soccer matches played throughout their training intervention in an attempt to quantify changes in match performance. Both SSG and GTG significantly ($p < 0.05$) increased their total distance covered (6%) and high-intensity activity (18%) during the matches when comparing pre- to post-intervention. In addition, pooled data indicated that the mean heart rate response increased by 2.66% ($p < 0.05$), indicating that the matches were being played at a higher intensity by the end of the training intervention (Impellizzeri et al., 2006). However, these results are inconclusive as there was no indication of whether the increased running and physiological response resulted in a successful outcome for the team. Practitioners should be aware that it has recently been noted that the most successful German Bundesliga teams do not cover the most distance or make the most high-intensity runs during games (Hoppe, Slomka, Baumgart, Weber, & Freiwald, 2015). The ultimate aim with any training intervention is for any physical improvements to translate into improved match performance and it may be that it is only necessary to obtain a minimal threshold level of fitness. Once achieved, technical and tactical performance may play a greater role in successful performance.

Summary of findings and recommendations for practitioners

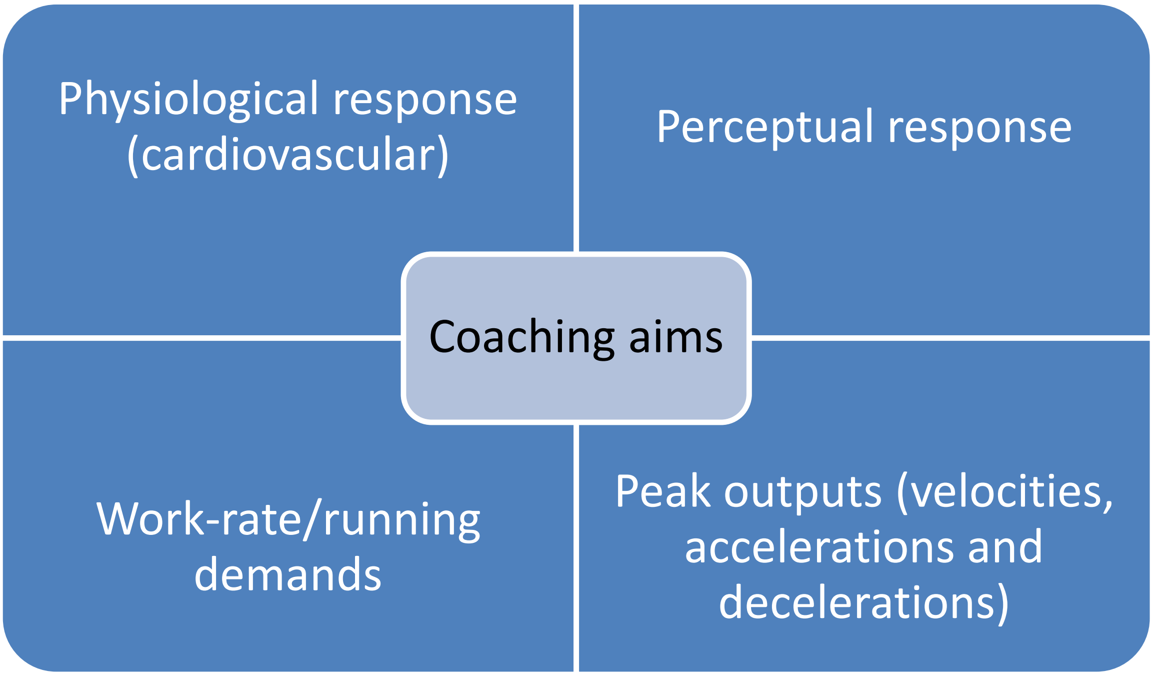

Figure 2: Summary of various coach objectives when using SSGs

As described in figure 2, existing studies in team sports have analysed the internal and external response to different SSGs. Current evidence suggests that SSGs are suitable for use as a form of high-intensity interval training if the goal is to improve aerobic fitness. This will most likely be the preferred option for coaches working either with young athletes or amateurs who are limited in training time as they are able to practice their technical skills simultaneously. Coaches should be aware that better or more experienced athletes are able to play at a higher intensity during SSGs than their lower level counterparts (Dellal, Hill-Haas, et al., 2011; Tim J. Gabbett, Jenkins, et al., 2012). There may therefore be a need to design or place certain conditions on the SSGs to ensure that all the players reach the desired intensities (Figure 3). To illustrate, Köklü et al. (2012) have shown that SSGs can be played at a high intensity by all players if teams are picked systematically according to fitness levels. Additionally, practitioners have used unbalanced teams (e.g. 4v3, 5v4) with a floater in order to physically overload individual players within a playing squad (Evangelos et al., 2012; S. V. Hill-Haas et al., 2010). The largest velocities, accelerations and decelerations have been found in large-sided games (LSG), however the existing studies would suggest that SSGs do not provide a suitable platform for obtaining peak power outputs (maximum sprints, high accelerations and decelerations). In that case, team sport athletes should possibly carry out supplementary general training (sprints, plyometric and resistance training). In particular scientists should look at the effects of combining GTG and SSG in future training studies rather than comparing both separately.

Information in the literature regarding the acute response of female team sport athletes of different ages and abilities to various SSGs is currently lacking. Additionally, not one of the published training interventions was carried out exclusively with females. Future studies should therefore add to the existing knowledge by replicating several of the studies that have been carried out with male athletes. There is a need for further SSG training interventions to make conclusive recommendations as only two of the existing training studies used a control group. Furthermore, training studies should seek practical ways of quantifying transfer of training to match performance as opposed to simply measuring changes in fitness tests. This may require future interventions to analyse a combination of physical, technical and tactical variables. In that regard, future training studies with all team sports would be enhanced by adopting realistic playing areas as measured with soccer players (Fradua et al., 2013). The ultimate aim of training should be transfer to match performance so it would make sense to analyse players' behaviours within realistic playing areas.

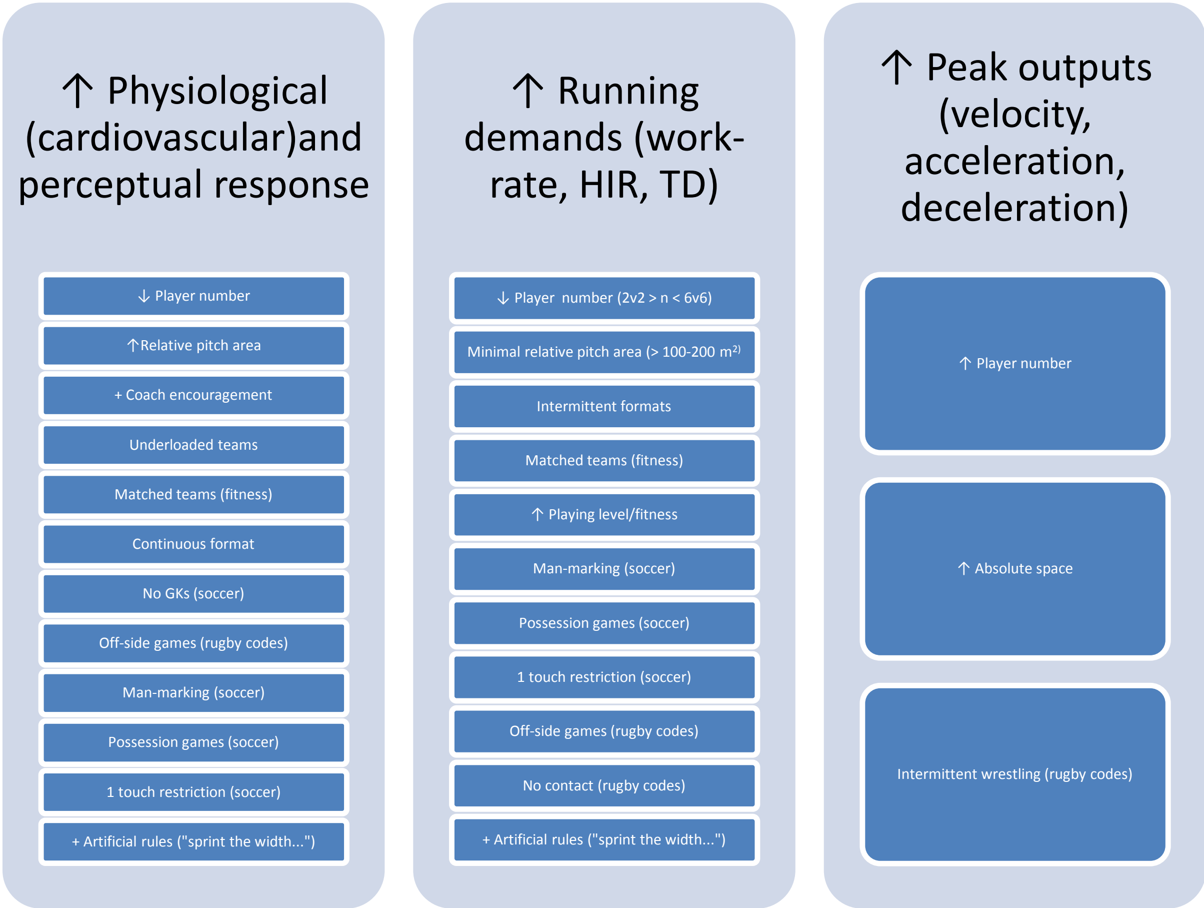

Figure 3: Summary of possible modifications depending on desired outcomes with SSGs

Part B: Technical Aspects of Small-sided Games

Acute response

SSGs have become popular amongst coaches as they allow players to practise specific movements and technique under pressure in a realistic context. Most SSG studies to date that have considered technical aspects have used basic frequency counts of the sport's most common technical actions in response to player number or playing area size (Atli et al., 2013; Tim J. Gabbett, Abernethy, et al., 2012; Kelly & Drust, 2009; Klusemann et al., 2012; McCormick et al., 2012). It is apparent that across different team sports, the individual involvement in the game and the frequency of technical actions generally increases when games are played on a smaller pitch area or with fewer players (Atli et al., 2013; Filipe M. Clemente, Wong, Martins, & Mendes, 2014; Klusemann et al., 2012; A. L. Owen et al., 2014). For instance, junior male and female basketball players carried out 60% and 20% more technical actions respectively when SSGs were played with fewer numbers or in smaller areas (Klusemann et al., 2012). This was also observed in soccer where the lowest player numbers (2v2) resulted in the highest volume of technical actions (Filipe M. Clemente et al., 2014). In 5v5 soccer games, several technical actions increased in frequency as the playing area was reduced (David Casamichana & Castellano, 2010). For instance, a 3.7 fold reduction in the area of the pitch resulted in a 1.78 fold increase in interceptions, a 3 fold increase in dribbling and 2.27 fold increase in shots. In certain sports the design of the SSG can affect the specific type of technical actions that are performed with greater frequency. For example, soccer players carried out more short passes, dribbles and shots in smaller games (<6v6) whereas larger games (≥6v6) played on a bigger area resulted in more frequent long passes, crosses and headers (Katis & Kellis, 2009; Adam L. Owen et al., 2011; A. L. Owen et al., 2014). In a separate study, a smaller playing area resulted in a greater amount of shots and tackles (Kelly & Drust, 2009). Thus, in soccer games, practitioners could plan the SSGs based on the particular technical actions that they wanted to be performed more regularly. This type of study warrants further investigation in other team sports.

Some researchers have tried to provide a more detailed insight into the technical responses to SSGs by acknowledging the success ratio or efficiency of observed technical actions (Aslan, 2013; Filipe M. Clemente et al., 2014; Tim J. Gabbett, Abernethy, et al., 2012; Tim J. Gabbett et al., 2010; Harrison et al., 2013). For instance, elite rugby league players were able to maintain the volume and efficiency of technical actions when SSGs were played on a small or large pitch (Tim J. Gabbett, Abernethy, et al., 2012) and when they had intermittent periods of wrestling (Tim J. Gabbett, Jenkins, et al., 2012). This suggests that elite players could maintain a certain level of technical performance under varying conditions as well as physical duress. In games of bucket ball played on the same relative pitch area of 145 m^2, young team sport athletes had more successful shots in addition to showing a trend for more successful passes (89.3±7.5% vs. 84.3±12.3%) during 3v3 games compared to 6v6 games (Harrison et al., 2013). These results suggest that with young performers, the number of players affects the quality of technical performance. The practitioner could therefore adapt SSGs to the physical and technical ability level of the participants through manipulations of certain key variables such as player number or the size of the playing area.

Variables that affect the acute technical response

Several authors have looked at the technical response in athletes as a result of manipulating different variables within the SSGs. Male soccer players were able to maintain the volume of technical actions as well as the success ratio of their passing during SSGs played with different bout durations (Fanchini et al., 2011). The players were able to maintain their technical performance regardless of whether the games lasted 2, 4 or 6 minutes (Fanchini et al., 2011). Further studies are warranted with younger players, lower level players as well different sports to determine whether these recommendations can be generalised. This is worthy of consideration as other team sports have unique demands with some involving frequent collisions and contacts (rugby codes), some in which the ball is manipulated with the hands (handball, basketball) and some in which there is need to manipulate an additional object (hockey).

Soccer coaches often used different formats within the SSGs such as possession games, target/support players, small target goals, end lines as well as regular goals and goal keepers (Filipe M. Clemente et al., 2014; Dellal, Chamari, et al., 2011; Halouani et al., 2014; Mallo & Navarro, 2008). Possession games resulted in greater number of individual contacts with the ball, short passes as well as passing errors than SSGs played with goalkeepers or outside supporting players (Mallo & Navarro, 2008). Equally, the number of attacking actions as well as efficiency was highest in end-line games compared to SSGs with goals and goalkeepers (Filipe M. Clemente et al., 2014). Several studies have looked at the use of touch restrictions during SSGs on the resulting technical performance with elite soccer players (Dellal, Chamari, et al., 2011; A. Dellal, B. Drust, et al., 2012; Dellal, Hill-Haas, et al., 2011; Dellal, Lago-Penas, et al., 2011). The technical performance was lowest when players were only allowed one or two touches on the ball and the speed of the game increased. To illustrate, the ratio of successful passes was 44.7-53.1% in one-touch games, 63.7-70.8% in two-touch and increased to 69.9-75.9% in free play games (Dellal, Lago-Penas, et al., 2011). These ratios were lower than the reported match successful pass ratio of 78.8% (A. Dellal, A. Owen, et al., 2012). Therefore SSGs played in small spaces and with restrictions placed on the number of touches were technically more demanding than official competition. The effects would most likely be greater with younger or lower ability players so practitioners should introduce this condition gradually throughout their development.

Rugby league players had a greater number of individual possessions as well as successful passes during off-side games compared to on-side games (Tim J. Gabbett et al., 2010). An important question to consider however is whether training performance during modified SSGs played with different rules and formats is transferable to match performance? In this regard, Tim J. Gabbett et al. (2010) remarked that despite the technical benefits of allowing players to receive the ball in off-side positions the cognitive load was lower. The suggestion was that the long-term learning benefits from the modified SSG were also potentially lower. There is clearly a trade-off between the usefulness of an SSG as a generic drill for technical development and its similarity with competition demands.

Comparisons

Experienced/professional vs. Novice/amateur

Players with greater experience or playing ability were distinguished from their counterparts through their technical performance to a larger degree than their physical performance (Vaz et al., 2012). Experienced rugby union players performed a higher number of passes and tackles than novice players in addition to scoring more tries (Vaz et al., 2012). In contrast, young elite rugby league players had an equivalent technical performance to their senior counterparts during SSGs (Tim J. Gabbett, Abernethy, et al., 2012). The main difference was that the senior players performed with a greater physical intensity (high intensity running, repeated sprints) than the junior players. Presumably the younger players had to slow the pace of the game in order to maintain the quality of their technical performance. The contrasting results found maybe due to the fact that the young players in the study by Tim J. Gabbett, Abernethy, et al. (2012) were high level players despite being a younger age. Indeed, the requirement for the junior elite rugby league players to transition to the senior team could be the ability to play with physical intensity whilst minimising technical errors.

In soccer, professionals were distinguished from amateurs by their superior playing ability when time and space were reduced as elite male soccer players had a better technical performance compared to amateurs in SSGs played with different player numbers and touch restrictions (Dellal, Hill-Haas, et al., 2011). The elite players made a higher percentage of successful passes and lost fewer possessions in every game played. Findings concluded that the ability to maintain technical performance when the SSG was played at a faster pace and with fewer touches on the ball allowed was the main difference between the two playing levels (Dellal, Hill-Haas, et al., 2011). Collectively, these studies illustrate that in order to play at a higher/professional level there is a clear requirement to maintain the quality of the technical actions whilst performing with a high physical intensity. Coaches of young and novice team sport players should therefore focus their training on improving the players' ability to play with speed and technical quality in small playing areas where time and space are limited. The optimal way of achieving this and sequentially planning the long-term technical development of young team sport athletes is currently uncertain and requires further research.

Position

In some sports the demands of the individual playing position affected the technical performance during SSGs. For instance, in young high school basketball players the point guard had significantly greater possession of the ball than other positions in 3v3 and 5v5 games (McCormick et al., 2012). This is important as coaches of young players in particular may want all their players to have equal opportunities to improve their technical actions during training. This study showed that the individual involvement of the participants was not homogeneous during SSGs. In soccer SSGs, the central defenders had the lowest technical performance compared to other playing positions (A. Dellal, A. Owen, et al., 2012). This was probably due to the fact that they were unaccustomed to playing in such small spaces during matches and therefore unfamiliar with the specific demands (A. Dellal, A. Owen, et al., 2012). Thus, it could be concluded that performing too many SSGs in small spaces would be unrealistic for central defenders. Alternatively, coaches may feel that exposing all players to SSGs in reduced spaces would be beneficial for their technical development regardless of their playing position.

Reproducibility and variation in technical performance

Given time-constraints and the need to maximise players' improvement during training sessions, the ability of SSGs to provide participants with consistent opportunities for technical development is an important factor for the coach to consider. The reproducibility of various soccer SSGs was high (ICC: 0.99, $p<0.05$) for major technical actions (A. L. Owen et al., 2014). Practitioners should be aware that this study was carried out with elite professional players and therefore a consistent technical performance during SSGs could be expected. In contrast, the individual variation (%CV) of the most frequent technical actions has been shown to be high with young developing athletes. For instance, the individual variation of technical actions in young soccer players ranged from 6.8-19.3% (da Silva et al., 2011). In elite junior basketball players the average variation was 34% (Klusemann et al., 2012). The variation was higher in high school female players as it was found to range from 18.6%-132.7% (Atli et al., 2013). The variation also increased when played in a larger court size. Finally, the use of intermittent wrestling during rugby league SSGs resulted in 14.3% of players having a reduced involvement in the play (Tim J. Gabbett, Jenkins, et al., 2012).

From these findings it is possible to make a few summary points:

1. The reproducibility of common technical actions during SSGs was consistent when measured with a squad of elite professional soccer players. However the same may not be observed in other sports or less experienced athletes.
2. The variation in the technical performance of young team sport athletes was high (CV > 10%). This has implications for coaches working with developing athletes wishing to ensure all players have a similar technical exposure during SSGs.

3. The manipulation of certain variables (pitch size, intermittent wrestling…) during SSGs may have an effect on the variation of technical actions. Coaches should be aware of this when planning SSGs

Change in technical performance across bouts

It has been observed in several studies that physical fatigue may occur across repeated bouts of SSGs. Findings have shown that physiological responses (HR, blood lactate) increase across successive bouts whereas physical outputs (high intensity running, sprints etc.) tend to decrease (da Silva et al., 2011; Dellal, Lago-Penas, et al., 2011; Kelly & Drust, 2009; Köklü et al., 2011). Several researchers have also investigated whether there is a concomitant drop in technical performance across multiple bouts of SSGs (da Silva et al., 2011; Fanchini et al., 2011; Tim J. Gabbett, Jenkins, et al., 2012; Kelly & Drust, 2009). However, research to date has revealed contrasting results with some authors reporting clear decreases in technical performance (Beato, Bertinato, & Schena, 2014; A. Dellal, B. Drust, et al., 2012; Dellal, Lago-Penas, et al., 2011; Kelly & Drust, 2009) whilst others only observed minor alterations (da Silva et al., 2011; Fanchini et al., 2011; Tim J. Gabbett, Jenkins, et al., 2012). For instance, the technical performance of international soccer players decreased throughout consecutive bouts of SSGs (A. Dellal, B. Drust, et al., 2012; Dellal, Lago-Penas, et al., 2011). The main performance measures were the number of lost balls and percentage of successful passes each bout. In addition, the results showed that the technical performance was always worst when the games were played with fewer players (A. Dellal, B. Drust, et al., 2012) or when a touch restriction (one or two touches) was placed on the games (Dellal, Lago-Penas, et al., 2011). The technical performance of elite players was significantly reduced after the first two bouts of SSGs, with 10-15.7% reductions in successful passes and increases of 231% in the number of lost balls despite the number of ball possessions staying the same (A. Dellal, B. Drust, et al., 2012). This observation is supported in amateur soccer players as passing accuracy was shown to drop from 74% to 44% (4v4) or from 78% to 57.5% (3v3) when comparing bouts 5 and 6 with the first one (Beato et al., 2014). In contrast elite rugby league players were able to maintain their total number of involvements as well as their passing and disposal efficiency across two bouts of SSGs with and without wrestling (Tim J. Gabbett, Jenkins, et al., 2012). Collectively these results illustrate the need for practitioners to be aware of the possibility of a gradual decrease in technical performance when games are played at a high intensity and performed over multiple bouts. There is some evidence to suggest that team sports played with hands may be more resistant to a decline in technical performance than sports played with feet (soccer). Ultimately, the ability to maintain technical performance may depend on multiple factors such as sport, age and ability level of the participants as well as the number of players, the number of bouts, rules and the playing intensity during the SSGs. Practitioners should consider all these factors when designing SSGs with their athletes as the current research does not allow for general recommendations.

Interventions

Although several studies have reported acute/descriptive comparisons of technical outputs in SSGs, there is very little research into the benefits of SSGs in training interventions to improve technical performance. This is also despite the often cited claim that SSGS are effective for skill/technical development. A. Delextrat and Martinez (2014) compared 6 weeks of SSGs to high intensity running (HIT) with junior basketball players and used a shooting and passing test to assess technical improvements. The SSG intervention resulted in a 7.4% improvement in the shooting test as opposed to the HIT group which had a 2.4% decrease in shooting performance.

Both groups made improvements (SSG: 6.7%; HIT: 9.8%) in the passing test following the intervention. Unfortunately this study did not assess technical improvements during SSGs or official matches. It used two unopposed technical tests in which players were timed and had to score as many points as possible. There is still a need for interventions in which there is a realistic assessment of technical performance during SSGs and official competition.

Future directions

There is clearly a need for further research into the technical response during SSGs and how this ultimately relates to match performance. In that regard, as mentioned in the physical response section, technical responses should be monitored in representative playing areas (Fradua et al., 2013). This is essential if the ultimate goal is to translate performance during SSGs over to performance during official competition. Practitioners should therefore look at the realism of certain drills. For instance, possession games are used by many soccer coaches and have been shown to elicit higher playing intensities with a high number of individual possessions (Dellal, Chamari, et al., 2011; Dellal, Hill-Haas, et al., 2011). However, possession games are non-directional and do not require the use of goals and goal keepers. Does technical performance during non-directional possession games translate to official soccer competition? It seems that certain exercises have been manipulated to produce physiological and/or technical outcomes but whether this translates to better performance in official competition is hard to quantify.

Researchers need to look at ways of providing a more informative assessment of technical performance beyond simply recording a frequency count of common technical actions. This could be done by developing new subjective/qualitative scales (Kempton, Sirotic, Cameron, & Coutts, 2013). This would need to be done in consultation with sport experts such as coaches but has the potential to provide more useful information to practitioners. Researchers should look at different ways of acknowledging the effectiveness of the technical actions in addition to a basic successful/unsuccessful count. For example, a player may make a high number of successful (efficient) passes in a game but they could all be ineffective or only slightly effective. A teammate may only make a fraction of the passes but manage to create several goal-scoring opportunities for the team. Figures 4 offers a theoretical example of how the information provided during technical analysis could be improved.

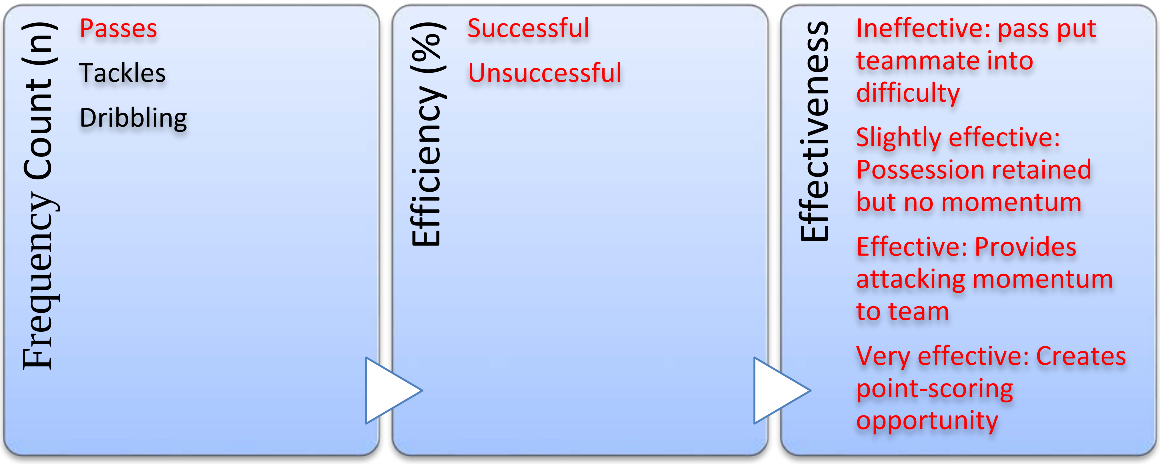

Figure 4: Example of proposed method for carrying out technical analysis

Finally, there is a need for training interventions which look at technical performance (effectiveness) during SSGs and official competition as an outcome measure.

Part C: Tactical aspects of small-sided games

The final component that should be addressed when designing team training sessions is the development of tactical knowledge (Filipe Manuel Clemente & Rocha, 2013). Tactical knowledge consists of principles or rules which enable players to find effective solutions to the multitude of situations that they will face during the game (Costa, Garganta, Greco, Mesquita, & Maia, 2011). Tactical training therefore should teach players to respond to specific stimuli and carry out various tasks during a match according to constraints such as time, space and location of the ball as well as the positioning of teammates and opponents (Filipe Manuel Clemente & Rocha, 2013). It follows that players who have accumulated greater tactical knowledge should have a greater speed of perception and execution during the game as well as being more efficient in their movements. While physical aspects have been explored in detail and technical demands less so, even fewer have considered tactical elements (J. Sampaio & Maçãs, 2012). However, sport scientists and coaches should have a method of quantifying and evaluating tactical performance during the SSGs in order to assess the impact on performance.

Tactical behaviour can be defined as a series of actions taken by players aiming to solve match problems in the most proficient way (P. Silva et al., 2014). Various assessment tools have been used to measure tactical behaviours including the System of Tactical Assessment in Soccer (FUT-SAT), the GK3-3GK test and the Offensive Sequences Characterization System or OSCS (C. H. Almeida, Ferreira, & Volossovitch, 2012; Costa, Garganta, et al., 2011; da Costa, Garganta, Greco, Mesquita, & Afonso, 2010). Alternatively, some authors believe that teams should be treated as ‘super organisms’ and their collective behaviours analysed according to socio-biological models (Duarte, Araújo, Correia, & Davids, 2012). Several studies have subsequently used positional variables such as the surface area, team geometrical centre (centroid) and length/width dispersion to try and capture the complexity of team movement throughout a game (Folgado et al., 2014; Frencken, Lemmink, Delleman, & Visscher, 2011; Frencken, Van Der Plaats, Visscher, & Lemmink, 2013; J. E. Sampaio et al., 2014; Vilar, Duarte, Silva, Chow, & Davids, 2014). To summarise there have been two main ways of measuring tactical performance during SSGs.

1. Tactical performance analysis tool
2. Analysis of the collective positioning and interaction of players as the match evolves

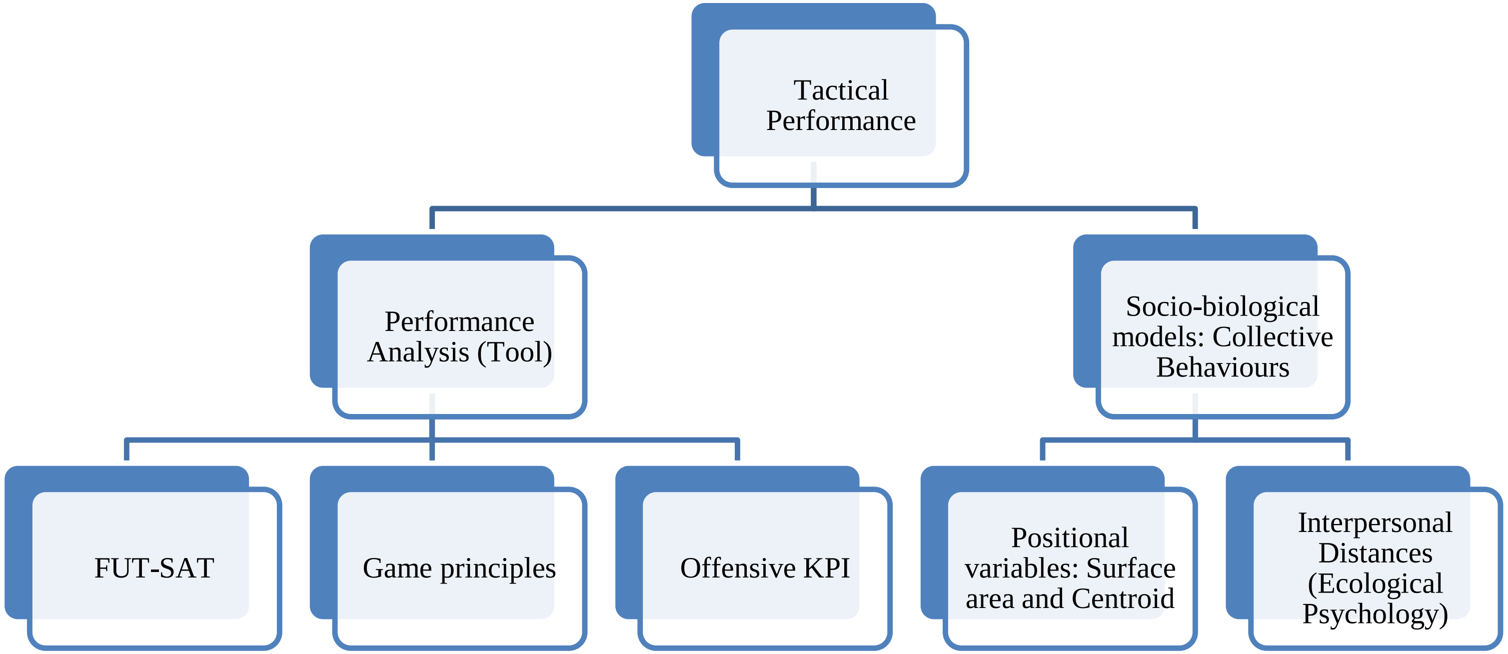

Figure 5: Summary of methods for analysing SSGs tactically

Table 6: Key variables using performance analysis tools

Authors	Sport	Participant ability level (age)	Player number	Variable of interest
(Costa et al., 2010; Costa, Garganta, et al., 2011; da Costa, Garganta, Greco, Mesquita, & Afonso, 2010; da Costa, Garganta, Greco, Mesquita, & Seabra, 2010; Santos, Resende, & da Costa, 2013)	Soccer	Youth teams (U11, U13, U15 and U17)	3v3 + GKs	Offensive and defensive principles, location of action, action outcome, tactical performance index (IPT), tactical actions, percentage errors, relative location of action principles (LARP)
Silva, Garganta, Santos, and Teoldo (2014)	Soccer	Youth team (U11)	3v3 + GKs 6v6 + GKs	Offensive and defensive principles, place of action, action outcome
(C. Almeida, H., Ferreira, & Volossovitch, 2013; C. H. Almeida et al., 2012)	Soccer	Non-experienced : PE class (12.84 ± 0.63) Experienced: Youth team (12.91 ± 0.59)	3v3 + GKs 6v6 + GKs	Duration of ball possession, players involved, ball touches, players involved/duration, ball touches/duration, passes/duration, ball touches/players involved, passes/players involved, passes/ball touches

Table 7: Key positional variables

Authors	Sport	Participant ability level (age)	Player number	Variable of interest
Frencken et al. (2011)	Soccer	Amateur team (22 ± 3)	4v4 + GKs	Centroid position, centroid displacement in forward-backward, lateral and radial direction, length and width of team, surface area
J. Sampaio and Maçãs (2012)	Soccer	University students (20 ± 0.1)	4v4 + GKs	Player (X,Y) coordinates, distance to team geometric centre, relative phase values for inter-player coordination
Frencken et al. (2013)	Soccer	Young professional (17.3 ± 0.7)	4v4 + GKs	Longitudinal and lateral inter-team distances, surface area differences
Folgado et al. (2014)	Soccer	Youth team (U9: 8.5 ± 0.53; U11: 10.4 ± 0.52; U13: 12.7 ± 0.48)	3v3 + GKs 4v4 + GKs	Length/Width ratio, centroid distance
J. E. Sampaio et al. (2014)	Soccer	Amateur team (20.8 ± 1)	4v4 + GKs	Distance to team centroid, randomness in distance to team centroid
(P. Silva et al., 2014)	Soccer	National level youth (16.2 ± 0.63) Regional level (15.6 ± 0.52)	4v4 + GKs	Dominant region, centroid distance to center of goal, stretch index, horizontal and vertical line forces
Vilar et al. (2014)	Soccer	University students (21.87 ± 1.96)	5v5	Interpersonal distances, relative distance for defenders to intercept pass/shot
Aguiar, Gonçalves, Botelho, Lemmink, and Sampaio (2015)	Soccer	Young professional (18 ± 0.67)	2v2 + GKs 3v3 + GKs 4v4 + GKs 5v5 + GKs	Team centroid, distance to team centroid, distance to opponents' centroid, distance between centroids

The next section will describe how the various assessment tools have been used to analyse the acute tactical response during SSGs.

FUT-SAT

The FUT-SAT is a valid and reliable tool (Costa, Garganta, et al., 2011) which enables scientists to collate and assess attacking and defensive tactical behaviours as well as the location on the field and the outcome of the action. The original set-up consisted of 6 outfield players and 2 GKs (3 + GK vs 3 + GK) playing a 4 minute game on a 36 m × 27 m pitch (Costa, Garganta, et al., 2011). Players are rated according to the efficiency and effectiveness of their tactical actions to generate a final tactical performance score (Costa, Garganta, et al., 2011). There have now been various studies with FUT-SAT which have analysed young soccer players' tactical performance according to chronological age/experience (da Costa, Garganta, Greco, Mesquita, & Afonso, 2010; Santos et al., 2013), the relative age effect (da Costa, Garganta, Greco, Mesquita, & Seabra, 2010), pitch size (Costa, Julius, Greek, Mosque, & Muller, 2011), player number (B. Silva et al., 2014) and goal size (Costa et al., 2010).

There have been a number of important findings for the practitioner working with young players. The total number of tactical actions performed by young soccer players during the SSGs increased with age (da Costa, Garganta, Greco, Mesquita, & Afonso, 2010). In addition, the tactical performance score was the biggest discriminating factor at the oldest age groups with the biggest differences occurring between the U-17 and U-20 group, thus illustrating the increased effectiveness of the tactical actions with oldest players (da Costa, Garganta, Greco, Mesquita, & Afonso, 2010). This could have very important implications for talent detection and identification in sport as tactical ability could be the crucial factor determining success once players reach a certain age. Furthermore, the relative age effect across several age groups (11-17 years) had no bearing on the efficiency and effectiveness of attacking tactical actions (da Costa, Garganta, Greco, Mesquita, & Seabra, 2010). This means that tactical ability is worth monitoring and may be the crucial factor to measure in talent identification programs.

There have also been a number of findings regarding defensive behaviours which appear to be affected both by player number and pitch size. For instance, in games of 3v3 + GK, U15 male players chose to press their opponents more aggressively on the bigger pitch (Costa, Julius, et al., 2011). Young soccer players (U11) chose to carry out more aggressive pressing in the opponents' half of the pitch during 3v3 compared to 6v6 SSGs (B. Silva et al., 2014). This may have been due to lower numbers and smaller playing space in the 3v3 making the game less complex for the young players. Taken together these two studies show how the design of SSGs affects the tactical behaviours of young players. More studies are warranted comparing different ages and ability levels; however player number and pitch size are two crucial variables to consider when analysing tactical behaviours with young players.

Offensive Sequences Characterization System (OSCS)

The OSCS is a notational analysis instrument which is used to generate an impression of the team's general tactical behaviour in possession of the ball by collecting a number of simple and composite variables (see table 6). Its application in SSG studies has revealed that deliberate practice experience has significant effects on tactical variables in SSGs (C. Almeida, H. et al., 2013). Specifically, experienced players tended to adopt a possession strategy with longer passing sequences and greater collective interaction whereas less experienced players used more individual actions. Experienced players also adapted to a greater extent to games with larger numbers (6v6) as indicated by longer attacking sequences with more ball touches prior to loss of possession (C.

Almeida, H. et al., 2013). This suggests that the ability to keep the ball and combine with teammates is a quality that needs to be developed with young players.

It is very common to place rules and conditions on SSGs in order to manipulate the physical and technical intensity. C. H. Almeida et al. (2012) analysed the effects of three different rules on the offensive tactical performance in 3v3 games with young soccer players and observed that using a “4 pass to score” rule resulted in greater ball circulation, duration of possession and number of players involved as well as a greater shot effectiveness (goal/shot ratio). This suggests that the rule conditioned the players to keep the ball and show more patience in waiting for better goal-scoring opportunities to manifest themselves. A “two touch” rule resulted in a quicker game and the “free play” rule produced more individual actions and 1v1 play (C. H. Almeida et al., 2012). Based on these findings, it appears that the optimal development of the young soccer player may require the appropriate combination of all three rule conditions.

Positional variables

Several authors have analysed tactical behaviours by looking at positional variables such as the surface area, team geometrical centre (centroid) and length/width dispersion (Duarte et al., 2012). Independent variables that have been manipulated include playing area size (Frencken et al., 2013; Vilar et al., 2014), age (Folgado et al., 2014) as well as speed of the game (J. E. Sampaio et al., 2014), ability level (B. Silva et al., 2014; P. Silva et al., 2014) and numerical relations (J. E. Sampaio et al., 2014; P. Silva et al., 2014).

Previous studies have shown that collective behaviours and tactical efficiency were affected by manipulations of the playing area size in soccer SSGs (Frencken et al., 2013; Vilar et al., 2014). When games were played on a shorter pitch, the longitudinal distance between the two teams decreased. The same effect was seen for lateral distance in response to a narrower pitch (Frencken et al., 2013). Finally, there was a crossover effect in which changes in longitudinal distances resulted in changes in lateral team distances and vice-versa (Frencken et al., 2013). It was suggested that coaches could select specific playing area dimensions to impact on the interactive behaviour between the players. A separate study conducted with university standard soccer players looked at the effect of playing area size on opportunities for attackers to maintain possession, shoot at goal or pass to another player (Vilar et al., 2014). It was found that smaller soccer pitches resulted in smaller distances between attackers and defenders (suggesting less opportunity to maintain possession) however there were no differences in opportunities to shoot or pass the ball (Vilar et al., 2014). There was a fairly consistent behaviour from the defenders, regardless of playing area, to allow the furthest attacker from the ball the greatest space to shoot. The authors suggested that lower level soccer players should practice on bigger playing areas as it would allow them greater time and space to play and keep possession (Vilar et al., 2014).

When comparing the tactical performance across age groups during SSGs, a notable difference was that the youngest players tended to spread out more in length than width (Folgado et al., 2014). In contrast the older players displayed a more consistent ability to use the width of the playing area. The consistency, expressed as a lower standard deviation, represents a higher playing level and collective tactical behaviour amongst the older players. The authors did point out however that variability with the novice player is an important stage of learning and should not be viewed negatively (Folgado et al., 2014). Presumably the standard deviation of collective behaviours could be useful for the practitioner to track over time to measure improvements in tactical performance. Regarding the length and width dispersal, some contrasting results were found. National level players displayed a greater elongation longitudinally compared to regional standard players on larger pitch sizes suggesting an attempt to reach the opposition's goal more quickly (P. Silva et al., 2014). This apparent selection of a more direct game style may have been caused by other factors such as the playing philosophy of the coach, lack of defensive organisation within the opposing team or the lack of off-side rule in SSGs. In addition the higher level player displayed greater variability in their distances to nearest opponents in smaller playing areas. This could indicate a greater ability of the higher level players to move off the ball in order to find space and lose their direct opponent (P. Silva et al., 2014).

The results of a recent study by J. E. Sampaio et al. (2014) with male soccer players, revealed that the average distance of each player to the team's centroid was unaffected by the speed of 5v5 games. However, the randomness of the distance increased with game speed (J. E. Sampaio et al., 2014). This suggests that players need a higher level of awareness and game understanding when the game is played at a higher speed. In addition, the distance to centroid and randomness were both lower when teams were in inferiority situations and losing the game (J. E. Sampaio et al., 2014). This was suggested to be evidence that the teams were playing in a more structured manner and were less willing to take risks in those two situations (J. E. Sampaio et al., 2014). Overall the collective positioning variables were better able to discriminate various game conditions (winning, losing, speed of game, team unbalance) than time-motion and physiological variables. This finding complemented a previous study with elite youth soccer players whereby the attacking team's centroid position crossed the defensive one prior to 53% of the goals being scored (Frencken et al., 2011). The conclusion was that surface area and team centroid were two variables worth monitoring as they help to describe collective attacking and defending behaviour.

Interventions

To our knowledge, there has been only one intervention study in the literature relating to tactical development and SSGs. J. Sampaio and Maçãs (2012) conducted a 13 week intervention in order to improve soccer players' tactical behaviours in a 5v5 SSG. The regularity of movements in length (d = 3.41) and width (d = 1.76) improved significantly ($p < 0.05$) following the intervention. Contrary to the rest of the findings, the regularity of player positioning at higher speeds (≥ $13 km.h^{-1}$) decreased significantly from pre to post intervention in both directions but especially in width (d = 4.04). This could indicate that a decrease in the regularity of player positioning at higher game speeds is a functional adaptation. The authors suggested that the ability to play in a coordinated manner at high speed and make effective use of the width of the playing area are two important qualities to develop in young soccer players (J. Sampaio & Maçãs, 2012).

Choice of field size to train tactically

In previous SSG studies, the authors do not always provide a reason for selecting specific playing area sizes. Fradua et al. (2013) mentioned that SSG playing areas for soccer should be designed according to the typical space that the players occupy during games. For instance, it was found that the effective space occupied by professional male soccer players during matches had a 1:1 or 1:1.3 length: width ratio and an individual playing area ranging from 65 m^2 to 110 m^2 (Fradua et al., 2013). In contrast, most soccer SSGs are designed with a greater length relative to width (B. Silva et al., 2014). Previous studies have also noted that realistic playing areas in soccer should include off-side lines and a distance ranging from 10-35 m between the defensive line and the goal keeper (Fradua et al., 2013; Zubillaga et al., 2013). It would be especially pertinent to analyse and track tactical performance within realistic playing areas. Future investigations should establish the effective playing areas within different sports and across different ages and ability levels. These could then be used to create more relevant SSGs.

Summary of main findings and practical applications

Despite some insightful acute, descriptive observations of the tactical behaviours of various cohorts of players during SSGs, there is a lack of research supporting or refuting the efficacy of SSGs as a tool to develop tactical behaviours. However, it is possible to make some observations according to studies to date:

1) Team sport players change their tactical behaviours according to the design (area size, player number) and conditions (4 passes to score, touch restriction) placed on SSGs
2) Players that have greater tactical knowledge and experience occupied the playing area space more effectively (P. Silva et al., 2014) and offered better supporting positions to teammates.
3) The ability to occupy the full width of the playing area in addition to length could be a sign of greater tactical expertise
4) The ability to develop effective possession and be patient in waiting for clear goal scoring opportunities comes with greater tactical knowledge.
5) Coaches should develop training sessions that help their players to maintain movement coordination at high playing speeds
6) Novice/younger players use a greater amount of individual actions in their play.
7) Younger or less experienced players should play with smaller numbers and/or be given greater relative playing space in order to be able to cope with the speed of

decision-making, keep possession of the ball and have more opportunities to shoot at the goal (C. Almeida, H. et al., 2013).

8) Coaches involved with long-term athlete development should note that tactical performance was not affected by the relative age effect in the same way as anthropometric and physiological measures (da Costa, Garganta, Greco, Mesquita, & Seabra, 2010)

Limitations, gaps and future research

The research is limited in this area and, to our knowledge, exclusively related to soccer. There is a need for future research to look at tactical behaviours across other team sports. The lack of research into the tactical behaviours during SSGs may be due to a lack of appropriate measurement tools and methodology (J. Sampaio & Maçãs, 2012). This review has shown that there have been some positive developments in this area in recent years with a number of different methods of measuring tactical performance but the ease of implementation is worth considering. For instance, how realistic is it for most coaches to measure and track changes in team positional variables after each training session? Time-motion and physiological data can now be collected and analysed very quickly, and viewed in real-time pitch side, however this doesn't appear to be the case for tactical tools.

Generally, SSGs have not been played in realistic playing areas (Fradua et al., 2013) and under realistic match conditions (off-side rule, 10-35 m distance between the GK and defensive line). This may explain why there have been mixed findings in terms of the use of width and length by various players (Folgado et al., 2014; P. Silva et al., 2014). Equally, SSGs may have some inherent limitations when used for tactical training. In that regard, some authors noted that young soccer players' ability to use the width and length of the field efficiently was not correlated with their tactical performance score (da Costa, Garganta, Greco, Mesquita, & Seabra, 2010). This means that the players' behaviour in the SSGs was not realistic compared to how they would be expected to play in full-sized matches. The authors suggested that this may be caused by the smaller number of players in the SSG (3v3) as well as the lack of off-side rule (da Costa, Garganta, Greco, Mesquita, & Seabra, 2010). Surface area oscillations of two teams were not negatively correlated in a game of 4v4 as might be expected (Frencken et al., 2011). Instead of seeing the expected pattern of the attacking team expanding and creating space and the defending team trying to eliminate space, the results suggested a certain amount of random movement within individual players. This suggests that soccer players displayed different behaviours in SSGs; rather, they had greater freedom of movement in the small games and potentially did not require the same tactical rigidity that they would need in full-sized matches.

Future research in this area should look at SSGs with bigger player numbers (> 6v6) which have a closer resemblance to official match conditions. Currently there is no evidence of whether different tactical behaviours can be improved in SSGs and whether these improvements can then be transferred to actual match performance. The studies in this review have mainly looked at general group behaviours and player interactions in small games (3v3-6v6). Surely the ultimate goal is to use training sessions to improve tactical performance in full-size games? As of yet it is unclear how coaches can transfer the learning from small games (2v2, 3v3, 4v4) to official competition. Equally, all coaches should have a defined team model according to his or her tactical principles and subsequently plan the training sessions to teach these to the players (Filipe Manuel Clemente & Rocha, 2013). Future research should present example case studies describing different ways of using SSGs for teaching a tactical team model to a group of players. Finally, there is a great need to be able to quantify the most relevant expert tactical behaviours in comparison to novices. In this way, practitioners will be able to map out the pathway from novice to expert and design appropriate long-term training programmes.

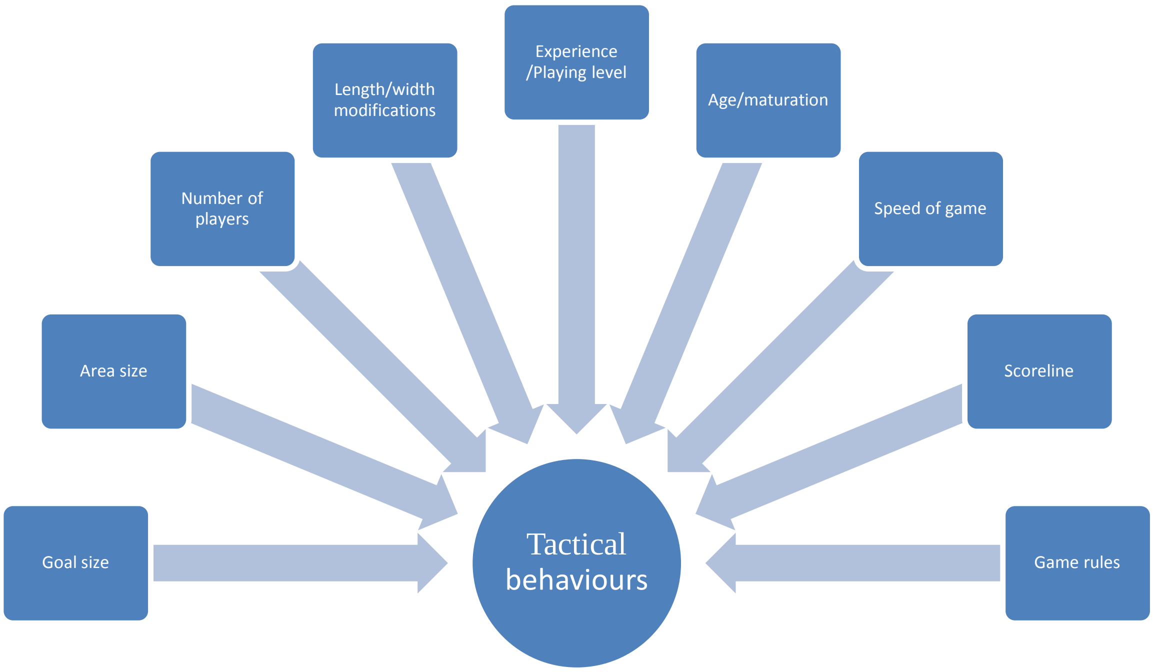

Figure 6: Variables that could modify tactical behaviours during SSGs

CHAPTER 3: METHODS

Experimental Approach to the Problem

We adopted an acute observational approach to examine the effects of manipulating field size during soccer small-sided games. All participants played a series of different SSGs during the competitive season whereby the playing area length: width ratio was manipulated according to previous recommendations for creating realistic soccer SSGs (Fradua et al., 2013). The SSGs consisted of two different player number formats (3v3 and 4v4) and two different lengths: width ratios (1: 1 and 1: 1.3) during which a range of measures were determined including physiological, perceptual, time-motion and technical responses.

Table 8: Participant characteristics

Age (years)	Body mass (kg)	Height (cm)	V_{IFT} (km.h^{-1})	V_{O2} max (ml.kg^{-1}.min^{-1})	Max. HR (bpm)	MSS (km.h^{-1})
16.2±1.4	59.3±6.6	166.2±6.5	17.9±0.9	45.2±1.7	202±8.5	25.9±1.5

VIFT: Peak speed obtained at the end of the 30:15 intermittent shuttle test; **MSS:** Peak sprint speed

Participants

Thirteen young female soccer players participated (table 8). The training group was made up of defenders (n=5), midfielders (n=4) and attackers (n=4). All participants were members of the same team competing in the highest national youth league and had a mean playing history of 7±1.2 years at the time of the study. Players typically trained 3-4 times each week and played two competitive matches. All the players and parents were provided with an information sheet containing details about the procedures, risks and benefits of participation prior to giving written consent. The study was approved by the AUT research ethics committee.

Table 9: Description of SSGs used in the study

Player number	3v3		4v4	
Bout number and duration (min)	4×4			
Recovery duration (min)	2			
Field area (m^2)	484	475	625	616
Area per player (m^2)	77-80			
Field size	22×22	19×25	25×25	22×28
Length: Width ratio	1:1	1: 1.3	1: 1	1: 1.3
GK area length (m)	15			
GK	No			
Coach encouragement	Yes			
Offside law	Yes			

Procedures

The study took place in the middle of the players' competitive season. During 3 weeks prior to the study, players were familiarised with the different SSG formats, the RPE scale as well as the heart rate monitors and GPS units. The team's coach was asked to rate each player's skill. The skill assessment included 3 categories: 'Dribbling/staying on the ball', 'passing and receiving' and 'game sense' and was developed in consultation with a UEFA A licence coach with over 30 years of experience and a UEFA B licence coach with 8 years of experience. During the week prior to the start of the study, the players completed the 30-15 Intermittent Field Test (M. Buchheit & Rabbani, 2014) to determine peak high-intensity running velocity (V_{IFT}) and heart rate, and 3× 40-m sprints with timed splits every 10-m. The fastest 10-m split was taken as the individual's maximum sprint speed (MSS). Players were then assigned to two teams for the SSGs, matched as close as possible according to fitness (VO_2 max) and skill scores as previously adopted (S. V. Hill-Haas, B. T. Dawson, et al., 2009; Köklü et al., 2012).

Small-sided games

The SSGs were played in random order over the study period and took place at the same time of day to minimise the effects of circadian rhythms on the recorded variables (Reilly, 2005). The games were always played at the start of the session following a standardized 15 minute warm-up (mixture of general physical exercises and specific ball-work). The playing area and length: width ratio was strictly controlled each training session (see table 9). The goals were positioned 15 m behind each end (offside line) of the playing area to replicate a GK area found in realistic playing conditions. The players were not allowed to enter the goal area before the ball. A specific rule was developed during the familiarisation period as it became apparent that it would not be possible to have 2 GKs consistently for the duration of the study: 2 attackers could enter the goal area and try to score with one recovering defender allowed to stop them. In addition the players could only score a valid goal by aiming for the corners and kicking the ball between the goal post and a cone placed 1.5 m away on the goal-line. The players were instructed to attack the goal as quickly and realistically as possible. Several soccer balls were placed inside the goals and alongside the pitch perimeter in order to restart play immediately when the ball was kicked outside the playing area. The team's coach and the principal researcher were present at each session and provided consistent verbal encouragement throughout the games. Each session consisted of 4 bouts of 4 minutes interspersed with 2 minutes of passive recovery. During the recovery period players were allowed to drink fluids ad libitum.

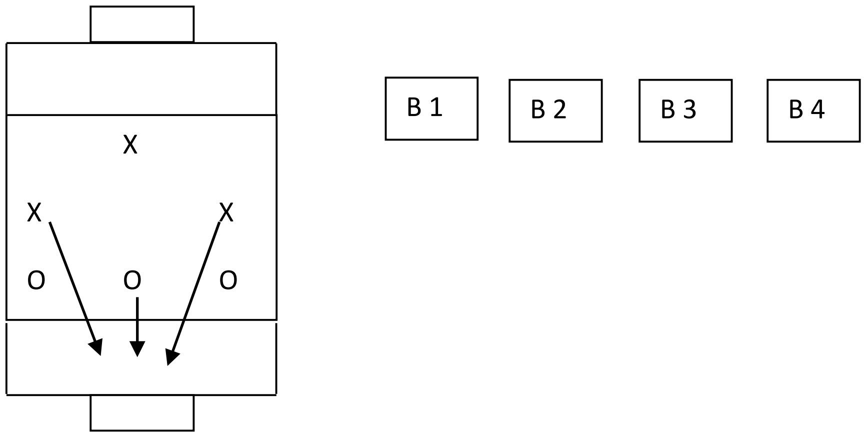

Figure 7: Representation of a 3v3 SSG played for 4 bouts of 4 minutes

Variables

Heart rate Monitoring

Each player's heart rate response was measured every 5 seconds during all SSGs using HR monitors (*Polar Team2 Sport System; Polar Electro Oy, Kempele, Finland*). The variables of interest were mean, minimum and maximum relative HR (%HRmean,

%HRmax and %HRmin respectively) during each bout. HR was reported as a percentage according to the peak HR obtained during the fitness testing (V_{IFT}).

Perceptual response

The 10-pt rating of perceived exertion (RPE) was used to collect a subjective impression of the exercise intensity following each SSG. Players were introduced to the RPE scale and the different anchor points during the familiarisation period prior to the start of data collection. Perceptual scores were collected immediately following the end of the SSGs.

Time-motion variables

During each SSG, all players wore a portable GPS unit (*MinimaxX v. 4.0, Catapult Innovations)* with a sampling frequency of 10 Hz. The 10 Hz units have recently been shown to have greater validity and inter-unit reliability for measuring team sport movement demands compared to 1 Hz, 5 Hz and 15 Hz units (R. J. Johnston et al., 2014; Varley, Fairweather, & Aughey, 2012). In accordance with manufacturer's guidelines, the GPS units were always activated at least 15 minutes prior to the start of the training sessions. Immediately following each session, data was downloaded for further analysis using specific software (*Catapult Sprint 5.1.1*). The mean (± SD) number of satellites available during data collection was 10.6 ± 0.8.

The variables used to quantify the physical demands of SSGs were: (a) total distance (TD), (b) distance covered per minute or 'work-rate', (c) distance covered in 3 different velocity bands: 0-8 $km.h^{-1}$ (low), 8.1-15.5 $km.h^{-1}$ (moderate) and >15.5 $km.h^{-1}$ (high); (d) distance covered in 3 different acceleration/deceleration bands: 1-2 ms^{-2} (low acceleration), 2-3 ms^{-2} (moderate acceleration), >3 ms^{-2} (high acceleration), -1-2 ms^{-2} (low deceleration), -2-3 ms^{-2} (moderate deceleration) and > -3 ms^{-2} (high deceleration).

The velocity bands were adapted from previous research involving young female soccer players (J. Vescovi, D., 2014; Vescovi & Favero, 2014). Similarly, the choice of acceleration bands was selected according to recent recommendations (Akenhead, French, Thompson, & Hayes, 2014; Castellano et al., 2013). Additional variables that were collected included peak running velocity ($km.h^{-1}$) as an absolute value as well as a percentage value relative to MSS and player load (AU).

Technical variables

All SSGs were filmed with a digital video camera (Sony HandyCam, HDR-CX130E, Sony New Zealand) from an elevated position overlooking the playing area. The main aim of the technical analysis was to assess the effectiveness of each player's individual possessions (involvements with the ball). Technical variables included: (a) total number of involvements; (b) involvements / minute; (c) effectiveness score; (d) effectiveness average; (e) different types of involvement. The effectiveness scale was developed with the same UEFA A licence coach who assisted in the skill assessment for group allocation at the start of the study. In order to determine the level of agreement between two observations by the same researcher (intra-rater reliability), intraclass correlations (ICC) were calculated for all technical variables. The same observer carried out a technical analysis on the same SSG twice with each observation separated by one week. Technical variables showed almost perfect levels of agreement (ICC ≥ 0.88) according to descriptive terms previously adopted (Davies et al., 2013).

Table 10: Effectiveness scoring scale used during the technical analysis

Action Outcome	**Effectiveness**	**Score pts**
Lose the ball	Ineffective	0
Put teammate in difficulty with pass resulting in loss of possession	Ineffective	0
Retain ball with no significant progress forward	Slightly effective	1
Square or backwards pass	Slightly effective	1
Forward pass but receiver is under pressure	Slightly effective	1
Switch play from pressure to provide forward momentum to ball carrier	Effective	2
Effectively retains possession under high defensive pressure without giving the team significant attacking momentum	Effective	2
Positive forward pass that provides attacking momentum to team	Effective	2
Dribbles across pitch and pulls defender out of position	Effective	2
Shot on goal	Very effective	3
Pass to teammate with good weight/timing, to correct foot that leads to shot on goal	Very effective	3
Individual creativity (combination, dribble) that disrupts opponent's defensive structure	Very effective	3

Statistical Analyses

Data are presented as mean ± *SDs* and the level of significance was set at $p \leq 0.05$. Analyses were carried out with the appropriate software (*SPSS statistics, version 22, IBM*). The effect of player number, length: width ratio and playing bout on physiological, time-motion and technical variables was examined using a generalized linear mixed model. The factor player number had 2 levels (3v3 and 4v4), the factor length: width ratio had 2 levels (1: 1 and 1: 1.3) and the factor bout had 4 levels (bout 1, bout 2, bout 3 and bout 4). Effect sizes (ES) were calculated and reported with 90% confidence intervals. The magnitude of the effect was classified as trivial (0-0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2) and very large (2-4) as suggested previously (Batterham & Hopkins, 2006).

CHAPTER 4: RESULTS

Physical

The mean (± SD) data for all SSG formats are shown in Tables 11-16. The player number had an effect on several GPS derived physical output variables. Specifically, the mean HR (large), work-rate (large), efficiency index (moderate), high speed distance (large), high deceleration distance (moderate), player load (small) as well as peak velocity (moderate) and %MSS (moderate) were all significantly greater for 3v3 than 4v4 (table 11).

Table 11: Comparison of physiological and time-motion variables for 3v3 and 4v4

Variables	3v3	4v4	% diff	ES
Mean HR (%HRmax)	0.85 ± 0.03*	0.81 ± 0.03	4.94%	1.51 (±0.83)
Work-rate (m.min^{-1})	97.04 ± 7.78*	87.56 ± 7.46	10.83%	1.24 (±0.8)
Eff. Index (AU)	1.15 ± 0.08*	1.07 ± 0.07	7.48%	1.10 (±0.79)
High Speed Distance (m)	25.89 ± 7.78*	16.14 ± 7.02	60.41%	1.32 (±0.81)
High Accel Distance (m)	4.61 ± 0.71	4.44 ± 0.67	3.83%	0.25 (±0.74)
High Decel Distance (m)	3.31 ± 1.04*	2.56 ± 1.01	29.30%	0.73 (±0.76)
Player Load (AU.min^{-1})	11.5 ± 2.15*	10.35 ± 2.15	11.11%	0.53 (±0.75)
Peak Velocity (km.h^{-1})	18.95 ± 1.11*	17.8 ± 1.11	6.46%	1.04 (±0.78)
Peak Velocity (%MSS)	0.75 ± 0.05*	0.7 ± 0.05	7.14%	0.93 (±0.77)

Accel: Acceleration; **Decel**: Deceleration; * = Significant difference between 3v3 and 4v4 ($p < 0.05$)

Regarding the length: width ratio, work-rate (small), efficiency index (moderate) and player load (small) were all significantly greater in the 1: 1 ratio compared to the 1: 1.3 ratio (table 12). Playing quarter only had a significant main effect on the efficiency index (F [3, 99] = 5.53, $p < 0.05$). The efficiency index in quarter 1 was 5.5% greater than quarter 3 ($p = 0.007$, ES = 0.78 ± 0.76, moderate) and 4.56% greater than quarter 4 ($p = 0.04$, ES = 0.56 ± 0.75, small). Quarter 2 was 4.6% greater than quarter 3 ($p = 0.03$, ES = 0.65 ± 0.75, moderate).

Table 12: Comparison of physiological and time-motion variables for 1: 1 and 1: 1.3 pitches

Variables	1: 1	1: 1.3	% diff	ES
Mean HR (%HRmax)	0.83 ± 0.03	0.83 ± 0.03	0%	0.00 (±0.74)
Work-rate ($m.min^{-1}$)	94.36 ± 7.75*	90.24 ± 7.53	4.57%	0.54 (±0.75)
Eff. Index (AU)	1.14 ± 0.08*	1.08 ± 0.07	5.55%	0.78 (±0.76)
High Speed Distance (m)	21.61 ± 7.62	20.42 ± 7.3	5.83%	0.16 (±0.74)
High Accel Distance (m)	4.36 ± 0.66	4.69 ± 0.73	-7.57%	-0.47 (±0.75)
High Decel Distance (m)	3.08 ± 1.04	2.8 ± 1.01	10%	0.27 (±0.74)
Player Load ($AU.min^{-1}$)	11.21 ± 2.15*	10.63 ± 2.15	5.46%	0.27 (±0.74)
Peak Velocity ($km.h^{-1}$)	18.44 ± 1.14	18.31 ± 1.08	0.71%	0.12 (±0.74)
Peak Velocity (%MSS)	0.73 ± 0.06	0.72 ± 0.06	1.39%	0.17 (±0.74)

Accel: Acceleration; **Decel**: Deceleration; * = Significant difference between 1: 1 and 1: 1.3 ($p < 0.05$)

Significant SSG × length: width ratio interactions were observed for mean HR, high speed distance, high deceleration distance as well as player load and peak velocity (table 13). When SSGs were played using a 1: 1.3 ratio, the mean HR (very large), player load (moderate), high speed distance (large), %MSS (large) and high deceleration distance (large) were significantly greater in 3v3 SSGs compared to 4v4 SSGs.

Table 13: Interaction effect of player number and length: width ratio on physical variables

Variables	3v3 1: 1	3v3 1: 1.3	4v4 1: 1	4v4 1: 1.3	Significant Effects†*
Mean HR (%HRmax)	0.84 ± 0.03	0.86 ± 0.03	0.83 ± 0.03	0.79 ± 0.03	SSG × 1: 1 = 0.33 (± 0.74) SSG × 1: 1.3 = 2.33 (± 1.12) †
Work-rate (m.min^{-1})	97.7 ± 9.04	96.4 ± 8.22	91.01 ± 8.03	84.9 ± 7.81	SSG × 1: 1 = 0.78 (± 0.76) SSG × 1: 1.3 = 1.43 (± 0.82)
Eff. Index (AU)	1.19 ± 0.09	1.11 ± 0.06	1.09 ± 0.08	1.05 ± 0.06	SSG × 1: 1 = 1.17 (± 0.79) SSG × 1: 1.3 = 1 (± 0.78)
High Speed Distance (m)	24.03 ± 9.71	27.75 ± 9.27	19.19 ± 8.6	13.09 ± 7.65	SSG × 1: 1 = 0.53 (± 0.75) SSG × 1: 1.3 = 1.72 (± 1.02) †
High Decel Distance (m)	3.21 ± 1.17	3.42 ± 1.17	2.96 ± 1.11	2.16 ± 1.04	SSG × 1: 1 = 0.22 (± 0.74) SSG × 1: 1.3 = 1.14 (± 0.94) †
High Accel Distance (m)	4.3 ± 0.79	4.92 ± 0.98	4.42 ± 0.79	4.46 ± 0.85	SSG × 1: 1 = 0.15 (± 0.74) SSG × 1: 1.3 = 0.5 (± 0.75)
Player Load (AU.min^{-1})	11.57 ± 2.21	11.43 ± 2.18	10.86 ± 2.18	9.83 ± 2.18	SSG × 1: 1 = 0.32 (± 0.88)* SSG × 1: 1.3 = 0.73 (± 0.90) †
Peak Velocity (km.h^{-1})	18.77 ± 1.3	19.13 ± 1.17	18.1 ± 1.26	17.49 ± 1.33	SSG × 1: 1 = 0.52 (± 0.75) SSG × 1: 1.3 = 1.31 (± 0.80) †
Peak Velocity (%MSS)	0.74 ± 0.06	0.75 ± 0.06	0.71 ± 0.06	0.68 ± 0.06	SSG × 1: 1 = 0.5 (± 0.75) SSG × 1: 1.3 = 1.17 (± 0.94) †

† = Significant effect sizes for SSG × 1: 1.3 interaction unless stated otherwise ($p < 0.05$).

* = Significant effect size for SSG × 1: 1 interaction ($p < 0.05$)

The efficiency index was greater on the 1: 1 pitch during quarters 2 (1.18 AU vs. 1.08 AU; F [1, 99] = 13.4, P = 0.000, ES = 1.11 ± 0.79, moderate), 3 (1.1 AU vs. 1.06 AU; F [1, 99] = 5.97, p = 0.016, ES = 0.44 ± 0.74, small) and 4 (1.13 AU vs. 1.04 AU; F [1, 99] = 10.17, p = 0.002, ES = 1 ± 0.78, moderate). Equally, the work-rate was higher when games were played on a 1: 1 pitch in quarters 2 (97.62 $m.min^{-1}$ vs. 90.28 $m.min^{-1}$; F [1, 99] = 5.04, p = 0.03, ES = 0.74 ± 0.76, moderate), 3 (93.05 $m.min^{-1}$ vs. 88.56 $m.min^{-1}$; F [1, 99] = 4.57, p = 0.04, ES = 0.53 ± 0.75, small) and 4 (95.36 $m.min^{-1}$ vs. 87.06 $m.min^{-1}$; F [1, 99] = 12.93, p = 0.001, ES = 0.92 ± 0.77, moderate). The high speed distance was higher on the 1: 1.3 pitches during quarter 3 (23.34 m vs. 14.43 m; F [1, 99] = 5.17, p = 0.03, ES = 0.84 ± 0.76, moderate). Finally, the high deceleration distance was greater on the 1: 1 pitch during quarter 4 (3.41 m vs. 2.55 m; F [1, 99] = 8.03, p = 0.006, ES = 2.35 ± 0.94, very large).

Perceptual

The reported RPE was significantly higher for 3v3 compared to 4v4 SSGs (7.44 ± 0.63 AU vs. 6.74 ± 0.63 AU; F [1, 118] = 86.03, p < 0.001, ES = 1.11 ± 0.69, moderate). There was a significant SSG × length: width ratio interaction. Games played using a 1: 1.3 ratio resulted in greater RPE values for 3v3 compared to 4v4 (7.86 ± 0.63 AU vs. 6.31 ± 0.63 AU; F [1, 118] = 563.94, p < 0.001, ES = 2.46 ± 0.84, very large).

Technical

There was no main effect of player number, length: width ratio or quarter for the number of involvements or the effectiveness of any technical action. The mean (± SD) technical outputs according to player number and length: width ratios are presented in Table 14. Individual player involvements averaged 1.51/minute in the 4v4 games using a 1: 1 ratio which was significantly greater than 1.29/minute when playing 3v3 games on a 1: 1 pitch (ES = 0.58, small, Table 14). The number of involvements was significantly greater in the 2nd quarter when games were played on the 1: 1 ratio compared to the 1: 1.3 ratio (moderate, Table 15).

Table 14: Interaction effect of player number and length: width ratio on technical variables

	3v3		4v4		Significant Effects*
Variables	**1: 1**	**1: 1.3**	**1: 1**	**1: 1.3**	
Involvements ($n.min^{-1}$)	1.29 ± 0.4	1.4 ± 0.4	1.51 ± 0.4	1.24 ± 0.4	SSG × 1: 1 = 0.55 (± 0.66)***** SSG × 1: 1.3 = 0.4 (± 0.65)
Effectiveness (AU)	8.6 ± 4.8	8.5 ± 4.4	8.02 ± 4.1	7.03 ± 4.3	SSG × 1: 1 = 0.13 (± 0.65) SSG × 1: 1.3 = 0.34 (± 0.65)
Effectiveness/Involvement (AU)	1.58 ± 0.6	1.57 ± 0.6	1.43 ± 0.6	1.46 ± 0.7	SSG × 1: 1 = 0.25 (± 0.65) SSG × 1: 1.3 = 0.16 (± 0.65)

* = Significant effect size for SSG × 1: 1 interaction ($p < 0.05$)

Table 15: Interaction effect of length: width ratio (LW) and quarter (Q) on technical variables

	1: 1				1: 1.3			
Variables	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Involvements ($n.min^{-1}$)	1.41 ± 0.4	1.53 ± 0.5*	1.3 ± 0.43	1.35 ± 0.43	1.4 ± 0.43	1.23 ± 0.4	1.35 ± 0.4	1.29 ± 0.5
ES (LW × Q)	**0.02 (± 0.65)**	**0.66 (± 0.66)***	**-0.12 (± 0.65)**	**0.13 (± 0.65)**				
Effectiveness (AU)	7.97 ± 3.21	8.97 ± 3.46	6.3 ± 3	8.9 ± 4.2	8.2 ± 3.1	6.9± 2.7	7.08 ± 3.1	8.36 ± 4.1
ES (LW × Q)	**-0.07 (± 0.65)**	**0.67 (± 0.66)**	**-0.25(± 0.65)**	**0.13 (± 0.65)**				
Effectiveness /Involvement (AU)	1.4 ± 0.47	1.6 ± 0.36	1.26 ± 0.5	1.55 ± 0.47	1.46 ± 0.4	1.44 ± 0.5	1.35 ± 0.5	1.6 ± 0.4
ES (LW × Q)	**-0.13 (± 0.65)**	**0.38 (± 0.65)**	**-0.19 (± 0.65)**	**-0.12 (± 0.65)**				

* = Significant effect size for length: width × quarter interaction ($p < 0.05$)

The individual variation in the number of involvements during each SSG ranged from 38% to 42% (table 16). The highest individual score obtained was 3 involvements.min^{-1} and the lowest was 0 obtained by one player during a quarter of the 4v4 played on a 1: 1.3 pitch.

Table 16: Variation of the number of individual technical involvements

Involvements (n.min^{-1})	3v3		4v4	
	1: 1	1: 1.3	1: 1	1: 1.3
Mean	1.32	1.36	1.46	1.22
High	2.5	2.25	3	2.5
Low	0.5	0.5	0.5	0
CV (%)	38%	35%	43%	42%

CHAPTER 5: DISCUSSION

The primary aim of this study was to compare whether alterations in the playing area length: width ratios during SSGs had any effect on the acute physical, physiological, perceptual and technical response of young female soccer players. To the authors' knowledge, the study provides novel data from young female soccer players as well as being the first to monitor player responses using realistic playing areas for SSGs, according to recent recommendations (Fradua et al., 2013; Zubillaga et al., 2013).

Physical responses and outputs – effect of player number

From a physical output perspective, the main finding was that player number had the biggest effect on both physiological and running responses regardless of the length: width ratio. Specifically, the playing intensity as shown by mean HR (4.94%), work-rate (10.83%), efficiency index (7.48%), high speed running (60.41%), high decelerations (29.30%), high accelerations (3.83%), player load (11.11%) and peak velocity (7.14%) was significantly higher during 3v3 SSGs compared to 4v4 (table 11). This is comparable to previous research involving male players of different ages and ability-level (Aguiar et al., 2013; Dellal, Chamari, et al., 2011; S. V. Hill-Haas, B. T. Dawson, et al., 2009; A. L. Owen et al., 2014). The mean HR responses during the SSGs in the present study were 85% HRmax for 3v3 and 81% HRmax for 4v4 which are lower than previous studies involving youth male players of similar age and using comparable bout durations (Brandes et al., 2012; Dellal, Chamari, et al., 2011; Koklu et al., 2013; Köklü et al., 2011; Köklü et al., 2012). For instance, 3v3 or 4v4 SSGs would typically result in HR response of approximately 90% HRmax in young (under 17) male players (Koklu et al., 2013; Köklü et al., 2012). In contrast, one previous study noted typical HR responses of 85% HRmax in male youth soccer players during 4v4 SSGs lasting 24 minutes (S. V. Hill-Haas, B. T. Dawson, et al., 2009), which is a comparable finding to the female players in the present study. We can only speculate about the reasons to explain the previous findings by S. V. Hill-Haas, B. T. Dawson, et al. (2009). In that regard, some authors have noted that physiological and perceptual responses could be expected to increase linearly with bout duration and be at their highest during one continuous bout of 24 minutes compared to various intermittent formats (Sampson et al., 2015). In contrast, recent research has noted that playing intensity dropped in rugby league SSGs lasting 12 min when the participants were given prior knowledge of exact bout duration (Tim J Gabbett et al., 2015). In future studies it may therefore be interesting to replicate the playing conditions used in this case whilst keeping the exact bout duration secret to the players.

The work-rate ($m.min^{-1}$) during SSGs in the present study was also lower than the majority of previous studies involving males. Recent research with youth male players suggested that an average work-rate of 103.3 $m.min^{-1}$ for an SSG lasting 5 minutes would be classified as slow (J. E. Sampaio et al., 2014). Furthermore, previous studies using similar player numbers and bout durations have found work-rates of 114.6 – 134.6 $m.min^{-1}$ (Köklü et al., 2015) or 116.6 – 118.3 $m.min^{-1}$ (Brandes et al., 2012) with talented youth male players of a comparable age to the females in the present study. Work-rates have even been reported to be as high as 198.5 $m.min^{-1}$ for elite male professionals during 4v4 SSGs (A. L. Owen et al., 2014). The general findings from SSG and match data suggest that work-rates during SSGs would be expected to be at least equal to or often higher than those found in matches (David Casamichana et al., 2012). The mean work-rates in this study were 97 $m.min^{-1}$ or 5.8 $km.h^{-1}$ for 3v3 and 87.6 $m.min^{-1}$ or 5.3 $km.h^{-1}$ for 4v4. Unfortunately we were not able to collect match data with this group of players in order to put those numbers into perspective. Additionally, there are no previous SSG studies using young females with which to compare these results. However, time-motion data from full matches reported in the recent FAiM project (J. Vescovi, D., 2014; Vescovi & Favero, 2014) can be used to understand the implication of these findings. J. Vescovi, D. (2014) carried out a time-motion analysis of young females (U16-U17) during a youth national championship and reported the average match work-rate to be 100 $m.min^{-1}$ (J. Vescovi, D., 2014). Subsequently, it was shown that female college players (U18 – U21) had typical match work-rates of 96 – 107 $m.min^{-1}$ but some individuals were able to obtain values as high as 120 to 130 $m.min^{-1}$ (Vescovi & Favero, 2014). These results suggest that work-rates for female soccer players increase at higher playing levels. Furthermore, in the modern game, elite professional female players do not differ greatly from their male counter-parts for work-rates during games and could be expected to cover a total distance of 10-12 km in a 90 minute match (Bradley & Vescovi, 2015b; Martínez-Lagunas et al., 2014). This would equate to an average work-rate of 111.1 – 133.3 $m.min^{-1}$. The results from the present study indicated that the mean work-rate in the 3v3 SSGs was similar to the typical match work-rate expected from young female players of that age (J. Vescovi, D., 2014). The mean work-rate for the 4v4 SSGs (87.6 $m.min^{-1}$) was slightly low. In summary, the young female soccer players in the present study should be aiming to increase their work-rates during SSGs and subsequently full matches to at least 100 $m.min^{-1}$ and look to increase that further as they get older.

The efficiency index (Effindex) has recently been used in match or training analyses for different team sports and is expressed as mean work-rate ($m.min^{-1}$) / mean heart rate (% HRmax) for the duration of the match (Luis Suarez-Arrones, Carlos Arenas, et al., 2014; Luis Suarez-Arrones, Javier Portillo, et al., 2014). This index has been proposed as a way of reporting the dose-response of a soccer match (L. Suarez-Arrones et al., 2014) and may even be used to detect the onset of fatigue (Halson, 2014) i.e. a greater reduction in movement relative to the heart rate response and therefore a decrease in the Effindex over the course of one or several matches (L. Suarez-Arrones et al., 2014). To the author's knowledge this metric has not been used previously to quantify the performance efficiency during soccer SSGs and therefore warrants further research. In the present study, the mean Effindex was significantly different ($p < 0.05$) when looking at the main effect of player number. The scores were 1.15 for the 3v3 and 1.07 for the 4v4 which as will now be explained, appear to be low when put into the context of official matches (Martínez-Lagunas et al., 2014). Assuming female players will have mean heart rates of 80-85% HRmax during matches (Martínez-Lagunas et al., 2014), this would result in a typical EffIndex of 1.31-1.39 for elite international female players, 1.26-1.34 for female college players and 1.18-1.25 for U16-17 players (Martínez-Lagunas et al., 2014; J. Vescovi, D., 2014; Vescovi & Favero, 2014). Furthermore, as there was no consistent reduction in running performance or Effindex across the playing bouts, as would be expected from previous studies (A. Dellal, B. Drust, et al., 2012;

Dellal, Lago-Penas, et al., 2011), it is unlikely that female players in this study played at a high enough intensity to develop fatigue during the SSGs.

To the author's knowledge, only one previous study has quantified the acceleration and deceleration demands of SSGs using 10 Hz GPS (Hodgson et al., 2014). Hodgson et al. (2014) suggested that practitioners should monitor acceleration and deceleration distance in order to gain a complete understanding of the demands of SSGs in which players do not reach high running velocities. In support, it has been shown that a high frequency of accelerations and changes in direction found during SSGs are metabolically demanding (Paolo Gaudino et al., 2014). Furthermore, SSGs were considered a useful training modality to overload and condition players specifically for the repeated acceleration/deceleration demands of match-play. Male university students played a total of 16 min (4×4 min) and carried out the greatest amount of high deceleration (34 vs. 18 m > - 3 m^{-2}) and high acceleration distance (38 vs. 23 m >3 m^{-2}) on a medium pitch compared to a small one (Hodgson et al., 2014). In the present study, high deceleration distance ($p < 0.05$) and high acceleration distance was higher in 3v3 compared to 4v4 SSGs. The players covered a mean of 4.61 m (3v3) and 4.44 m (4v4) of high acceleration distance as well as 3.31 m (3v3) and 2.56 m (4v4) of high deceleration distance in each of the 4 playing bouts. This indicates that the totals for the whole SSG (×4) would be slightly lower than the previous study (Hodgson et al., 2014) with university students (17.76-18.44 m vs. 23 m for high acceleration; 10.24-13.24 m vs. 18 m for high deceleration). In addition, the mean high deceleration distance was consistently lower than the high acceleration distance for both 3v3 and 4v4 SSGs irrespective of the length: width ratio. A similar observation was made previously during SSGs and was explained by the fact that players are typically stronger in eccentric muscle actions thus able to provide greater deceleration than acceleration forces (Hodgson et al., 2014).

Physical responses and outputs – Effects of playing area

Previous research has shown that pitch size can be influential with respect to physical outputs displayed during SSGs (David Casamichana & Castellano, 2010; Hodgson et al., 2014; Koklu et al., 2013). To our knowledge, this is the first study to consider realistic playing areas for SSGs extrapolated from official matches, including specific length: width ratios and an additional goalkeeper area (Fradua et al., 2013). The results indicated that manipulating the length: width pitch ratios for a given playing area seemed to have very little effect on the resulting playing intensity during SSGs or the metrics obtained from GPS and accelerometer regardless of player number (Table 12). As mentioned in the previous section, the playing intensity and physical outputs were low compared to research with male players which may be explained by the lack of necessary skill of the participants to play the SSGs at the required speed and intensity in small playing areas. In a previous review, it was suggested that lesser skilled players may struggle to reach high playing intensities during SSGs (S. V. Hill-Haas et al., 2011). In support of this statement, David Casamichana and Castellano (2010) reported that youth male players (15.5 ± 0.5 years) from a regional team displayed a work-rate of 87 $m.min^{-1}$ during SSGs played on a pitch allowing 73.6 m^2 per player (i.e. similar playing area to current study). The work rate had decreased from 125 $m.min^{-1}$ when using 272.8 m^2 per player. In addition the mean HR on the large pitch was 88.6% HRmax compared to 86% HRmax on a small pitch (David Casamichana & Castellano, 2010).The authors speculated that the smaller playing area had resulted in a reduction in the 'effective playing time' through frequent stoppages in play which would have subsequently disrupted the playing rhythm and resulted in decreased physiological and physical outputs (David Casamichana & Castellano, 2010). Rampinini et al. (2007) did not measure work-rate, however they reported that male amateur players (24.5 ± 4.1 years) had a mean HR response of 88.7-90.5% HRmax when 3v3 and 4v4 SSGs were played in as little as 40 m^2 of space per player. Those results were higher than the mean heart rates of 83% (1: 1 and 1: 1.3) found in the current study and illustrate that it is possible to play at a high intensity in smaller playing areas than the ones used in this study. However, the ability to do so may be dependent on the skill level and/or age of the participants to enable a continuous flow to the game. The principal aim of the current study was to assess the effects of various realistic playing areas for SSGs which included GK areas and offside lines. Accordingly, the intensity of play may have been slowed further than previous SSG studies as the game was more tactical requiring the players to think about what they were doing, pick the right moment to pass the ball and time their runs in order to not be offside. This is in contrast to previous studies which have resulted in high playing intensities by adopting unrealistic conditions in order to encourage increased activity such as touch restrictions and non-directional possession games (Castellano et al., 2013; Dellal, Chamari, et al., 2011; A. Dellal, B. Drust, et al., 2012).The evidence suggests that there may therefore be a trade-off for coaches working with younger players between the desire for an elevated physical intensity and speed of the game or a technical-tactical focus during SSGs.

In earlier studies, authors have reported that SSGs do not allow soccer players to produce the same amount of sprints and high intensity running as that found in full matches (David Casamichana et al., 2012; Tim J. Gabbett & Mulvey, 2008). The results of the present study add further evidence to that observation as the players on average, did not manage to make a single sprint in any of the game formats according to recent recommendations (Bradley & Vescovi, 2015a) which define 80-85% of an individual MSS as the minimum threshold to classify a sprint with young female players. In comparison, the average peak velocities during SSGs in the present study were 18.4 $km.h^{-1}$ (73% MSS; 1: 1) and 18.3 $km.h^{-1}$ (72% MSS; 1: 1.3) with no significant differences for the separate length: width ratios. The lack of absolute playing space possibly constrained the amount of high speed running and sprinting observed in this study. Preceding studies with elite male players have shown that higher velocities of approximately 25 $km.h^{-1}$ were only reached in larger sided games such 9v9-11v11 in which the coaches allowed 218-336 m^2 of individual relative playing space (A. L. Owen et al., 2014). Moreover, considering that the relative individual playing area was strictly controlled in this study (77-80 m^2), we suggest that the slightly higher amount of high intensity running and peak velocities observed in the 3v3 SSGs were caused by technical/tactical reasons. For instance, it is possible that player positioning and field coverage by the defending team was not adequate during the 3v3 SSGs. This would result in more open space for the attackers enabling them to reach higher running velocities.

In summary, the main observation from this study is that the movement and physiological demands of SSGs are relatively low in this group of young female players compared to previous findings. The playing area of 77-80 m^2 was small compared to several previous studies (Brandes et al., 2012; S. V. Hill-Haas et al., 2010; Adam L. Owen et al., 2011). However there was an additional 15 m of space at either end of the pitch (figure 8) which the players could accelerate into and enter with correctly-timed movement and thus potentially resulting in frequent sprints and high-intensity runs. This did not happen which could have been due to the technical/tactical levels of the players, their level of physical development, motivation or possibly a combination of these factors. The pitch layout and playing conditions (off-side rule) may also have caused the playing intensity to drop.

Technical responses and outputs

SSGs are popular with many soccer coaches as they are claimed to provide players with a platform to simultaneously improve technical and physical ability (da Silva et al., 2011; Kelly & Drust, 2009; Adam L. Owen et al., 2011). Presumably, technical improvements in SSGs would result from participants having greater involvement with the ball compared to an official match as a result of the reduced playing area and number of players (C. Almeida, H. et al., 2013). To illustrate, Adam L. Owen et al. (2011) reported 76.2% more individual ball contacts in 3v3 compared to 9v9 games. Regarding individual involvement, previous studies have indicated that elite male professionals will have possession of the ball approximately 0.6 times.min^{-1} during a 90 minute soccer match (A. Dellal, A. Owen, et al., 2012; Mallo & Navarro, 2008). To our knowledge there is no comparable research for female players of different ages and ability levels, although a recent study found no significant differences for total individual time (s) in possession of the ball (69.6 ± 4.1 vs 66.5 ± 3.4 s) and average touches/possession (2.1 ± 0.1 vs 2.1 ± 0.1) when comparing male and female champions league players (Bradley et al., 2014). In the present study, the technical performance was similar for all playing conditions, regardless of player number or pitch dimensions. When analysed by playing bout, the average contribution for each player was 1.3-1.5 involvements.min^{-1} (table 15). As observed for the physical outputs, this would seem to indicate a relatively low playing intensity and general involvement in the SSG. In comparison, as shown in figure 9, male players of varying age and ability level had 2-4 involvements.min^{-1} during 3v3 - 4v4 possession and target goal SSGs (da Silva et al., 2011; Dellal, Hill-Haas, et al., 2011).

The current study illustrated a relatively low individual technical involvement by several of the players which may be partly explained by the format of the SSGs.

Previous findings have shown that possession games or games with outside support players tend to result in greater playing intensity and individual contacts with the ball compared to SSGS with goals (A. Dellal, B. Drust, et al., 2012; Mallo & Navarro, 2008). Mallo and Navarro (2008) found that 3v3 SSGs with goalkeepers using elite male U-19 players resulted in 69.1% less involvements.min^{-1} than 3v3 possession games. However, in comparison the 3v3 SSGs without goalkeepers in our study resulted in 63-91% less individual possessions. Unfortunately, no data exists for female players of any level with which to compare our data to. Adam L. Owen et al. (2011) reported an average of 7.4 involvements.min^{-1} during 3v3 SSGs with goalkeepers using elite male professionals, which is almost five-fold greater than the present study suggesting that the relatively low individual involvements observed in our study is likely related to the current skill level of our participants.

In light of the opinion that SSGs enable players to improve technically, there should be some concern with the amount of between-player variations found within this group of young female players (table 16). In particular, our results show that some players had an adequate involvement in the prescribed SSG (2-3 involvements.min^{-1}), regardless of pitch size/ratio, whereas others had minimal involvement (<1 involvements.min^{-1}). Alarmingly, during a playing bout of a 4v4 SSG, one player had 0 involvements despite our efforts to balance the teams (table 16). Coaches working with young players in particular, may be interested in looking at different methods of picking teams and the resulting effect on the technical responses during SSG and other practice methods. For example, one study has reported methods for picking teams with the subsequent physical response in mind (Köklü et al., 2012) revealing that a consistent playing intensity amongst 32 young players is possible if teams for SSGs are balanced according to aerobic fitness levels. It would be interesting to research the effect of different methods for picking teams on the number of individual involvements in SSGs.

Specifically, is it possible to group players or organise the SSG in a way that allows all players an adequate number of involvements (2-4 involvements.min^{-1})? This is particularly relevant with many amateur teams such as in this study where there may not be homogeneous playing levels within the group.

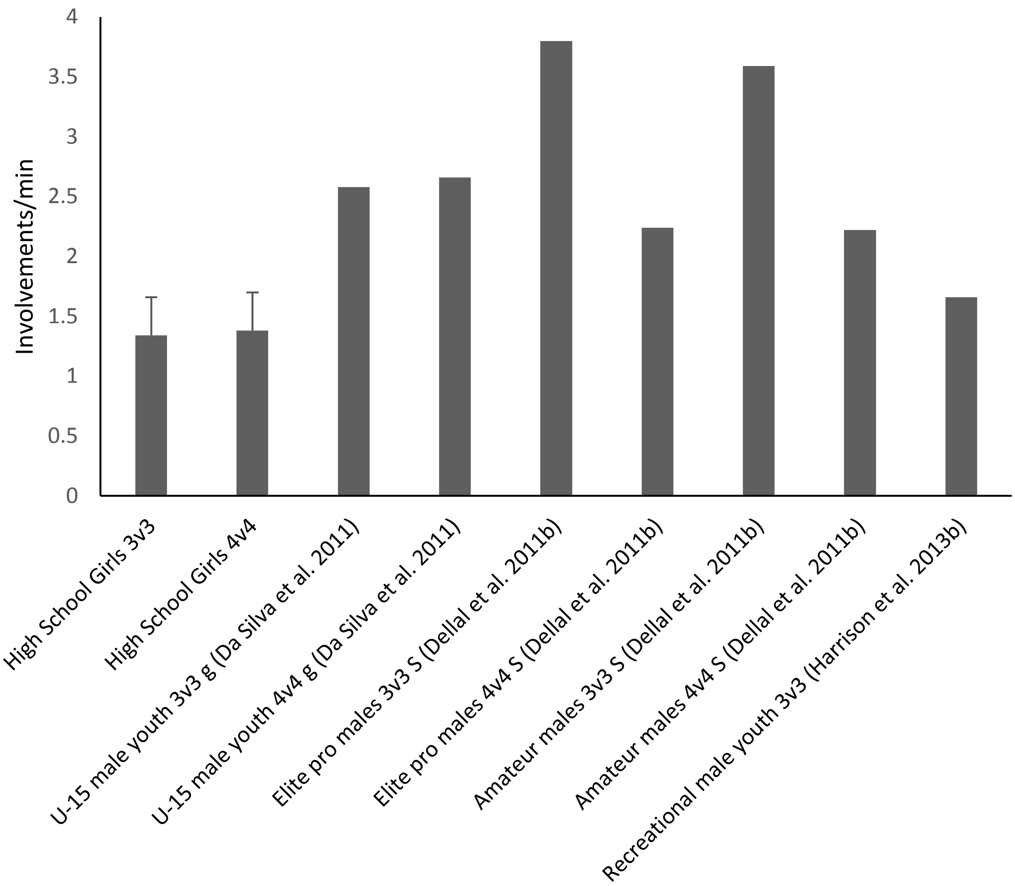

Figure 8: Comparison of current study with previous findings (estimated from reported values) for involvements.min^{-1} in SSGs

It is often claimed that technical performance can be developed via SSGs (David Casamichana & Castellano, 2010; Evangelos et al., 2012; Adam L. Owen et al., 2011). In this regard, most studies simply report the volume of technical actions performed (Adam L. Owen et al., 2011) and the efficiency or successful/unsuccessful ratios of such actions (Beato et al., 2014; Fanchini et al., 2011; Mallo & Navarro, 2008). Clearly, there is a need to develop the technical analysis further if we wish to find ways of tracking and quantifying changes in technical performance over time. For instance, does a small increase in the frequency of individual possessions during an SSG necessarily imply an improvement in technical performance? To address this limitation, we also considered the effectiveness of the technical actions as it is possible for any given player, during SSGs or in full matches, to be efficient with their individual possessions (i.e. 100% successful passes) whilst being ineffective at the same time. For example, this could happen if a player only passed sideways and backwards or put a teammate into difficulty with their 'successful' pass. The present study provides novel insights into the effectiveness of each individual's possessions during SSGs. Specifically, the mean scores during the SSGs were 1.43-1.58 AU for each involvement indicating that individual possessions were typically only 'slightly effective' (table 10). Noticeably, players tended to use simple playing options such as sideways and backwards passes with no intention to penetrate the opposition defence. Additionally, our results show that the young players made use of a simple technical vocabulary in the SSGs, consisting primarily of a control with their first touch followed by a basic pass with the inside of the foot (figure 10). Overall, our data shows that the young female players in the present study did not favour individual actions with the ball such as turns and 1v1 dribbling. We believe that young players in possession of the ball should be able to display an array of technical actions including dribbles, turns and passing variants (inside of foot, outside, chipped, driven, reverse passes etc.) in matches and SSGs. Furthermore, they did not use any combination play with teammates such as wall-passes and overlaps or variations in passing techniques. To our knowledge, no existing study has sought to quantify the range of techniques used by young players in SSGs in this manner. Indeed, some current research with elite youth male players (14-18 years old) has suggested that increasing the variability of attacking tactical behaviours and positioning during SSGs is crucial to play at a high level (Olthof, Frencken, & Lemmink, 2015). Future studies should therefore look at the range and quality of techniques used by male and female players of different ability levels during SSGs. This should be followed by investigations as to whether these can be improved with coaching interventions. Additionally, practitioners should analyse the efficacy of different coaching interventions for improving the effectiveness of individual possessions, not just frequency counts and success ratios. Furthermore, it would be useful for practitioners to gather 'effectiveness' benchmark scores from different players of varying ability levels participating in SSGs.

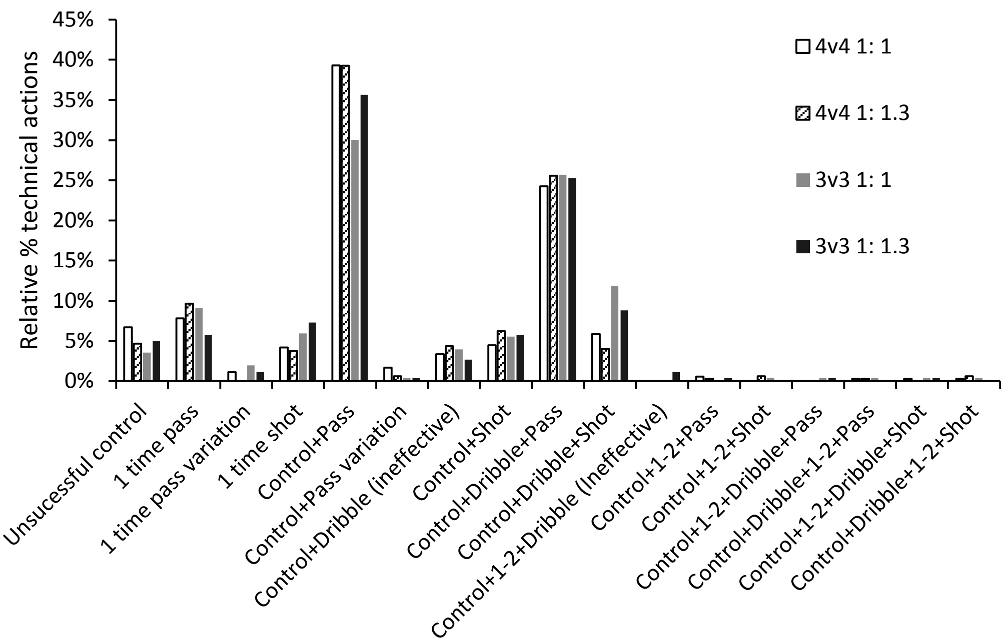

Figure 9: Breakdown of the various techniques used during individual possessions

Limitations

While the current study provides some novel data on the physical, technical outputs of young female players during various SSG formats, we acknowledge some limitations. Firstly, we wished to investigate the influence of pitch dimensions following the logical recommendations that playing areas used during SSGs should be based on the realistic positioning that a team would use during games according to their game style and playing philosophy (Fradua et al., 2013). This would result in the team occupying a specific area within the pitch throughout the game. Unfortunately we were not able to collect positioning data from actual matches with our participants, thus the SSGs were designed according to previous studies done with Spanish male and female professional soccer matches (Fradua et al., 2013; Zubillaga et al., 2013). The game style and therefore the positioning of the players in those previous studies could be unique to those teams and standard of player. Ideally, future SSG studies should try to extrapolate pitch areas and length: width ratios from match data from a variety of different teams, different age groups and ability levels using different tactics and strategies in order to design the most realistic playing areas for their training sessions. Equally we were not able to collect physiological responses (HR) and physical outputs (work-rate, high intensity runs) from matches with our players in order to compare to the data from SSGs.

The sample size (n=13) available for this study was small and is an undoubted limitation as it only allowed us to monitor acute physical and technical responses during 3v3 and 4v4 SSGs. The study would have benefited from being able to test the influence of pitch ratio dimensions with larger-sided (7v7 to 11v11) games in addition to the SSGs. It is possible that both the technical and physical outputs could be different when using different number of players and larger relative playing areas. For instance, it has previously been shown that there are significant differences in the physical outputs for male professionals taking part in different-sized games (A. L. Owen et al., 2014). Equally, differences in technical/tactical outputs would most likely be prevalent as larger numbers (>6v6) have been shown to result in a lesser volume of individual technical actions (Adam L. Owen et al., 2011) but a greater amount of "off-the-ball" tactical movements (C. Almeida, H. et al., 2013) compared to SSGs.

Finally, the lack of goalkeepers was a limitation as the purpose in the present study was to monitor acute player responses using realistic SSGs. Despite the fact that the omission of goalkeepers has been shown previously as a method for raising the intensity of SSGs (Castellano et al., 2013), this is done at the expense of the tactical realism of the drill.

Practical Applications

This study is the first to assess the physical, physiological and technical outputs during various SSGs and therefore provides some benchmarks for young developing female soccer players participating in SSGs. Such data will be useful for coaches, strength and conditioning practitioners as well as researchers interested in developing female players. It would seem that length: width ratio is not the most important factor for determining the resulting physical and technical responses when playing 3v3 or 4v4 SSGs in this cohort of developing female players. Thus practitioners could potentially use either length: width ratio (1: 1 or 1: 1.3) for SSGs. Instead, it would seem player number is a crucial variable for determining the playing intensity in SSGs. Specifically the coach should choose 3v3 over 4v4 SSGs if he/she wants to achieve the greatest physiological and running responses. However, the playing areas and game format in this study likely did not result in high enough playing intensities to provide a substantial aerobic conditioning stimulus (> 85% HRmax) (Hoff et al., 2002). Additionally, the players were seldom exposed to high speed running or accelerations. On that basis, it would seem that the SSGs used in this study may be best used for technical/tactical training rather than conditioning with these participants. It is unclear whether the low playing intensity was caused by the rules and playing area used for the SSGs, the technical ability or the fitness levels of the players used in this study.

Future Directions

Martínez-Lagunas et al. (2014) recently stated that research into the female game is still lacking compared to their male counterparts. Specifically, there is a general lack of data on female players taking part in SSGs, especially at the developmental level. Given the growth and recent increased professionalism of the female game there is a need for ongoing research in order to refine the training process and improve match performance. Future studies should therefore measure the physical and technical performance of female players of different abilities in similar playing areas to the ones used in the current study. This would provide some benchmark scores and indicate whether the low physical outputs in this case were caused by the design of the SSGs or the physical/technical capabilities of the young players.

The recommendations for realistic SSGs on which this study was based actually included a range of playing area sizes (65-110 m^2) depending on ball position and whether the team was building up play from the back, keeping the ball in midfield or attacking the opponents' goal (Fradua et al., 2013; Zubillaga et al., 2013). Future studies should therefore assess whether the length: width ratio has a greater effect with certain playing area sizes. Additionally, studies with larger sample sizes should monitor the effects of different sized games. For instance, it would be helpful to measure the acute responses and outputs with medium-sided games "MSGs" (5v5 – 8v8) as well as large-sided games “LSGs” (9v9 – 11v11) in order to compare them to the SSGs used in this study.

The technical analysis found that the overall involvement of the players through individual possessions was low compared to some previous SSG studies using male players (Adam L. Owen et al., 2011). In addition the effectiveness of the players' individual possessions and variety of skills used in the SSGs were limited. Researchers should therefore analyse the effectiveness of individual possessions during SSGs as in this study and subsequently whether it can be improved in the developing player via specific training interventions would be worthwhile to explore. Previous research has noted that smaller playing spaces typically resulted in more defensive pressure and less opportunities for players to maintain possession (Vilar et al., 2014). The implication was that coaches may need to use bigger spaces initially with less developed players and then look to decrease the playing area as players improve. Overall, there is a clear need for training studies to determine the usefulness of different coaching interventions on technical performance with young soccer players. The goal then would be for the players to eventually be technically able to maintain possession in the same playing spaces that they are likely to encounter in competitive matches.

Finally, future studies should analyse the quality of the tactical movements and positioning as per current research (Aguiar et al., 2015; Folgado et al., 2014; Frencken et al., 2011; J. Sampaio & Maçãs, 2012). In the current study we analysed the effectiveness of technical actions, however this should be supplemented with an assessment of tactical performance. To illustrate, Folgado et al. (2014) noted that older and more experienced players made greater use of the width of the playing area in SSGs. Future studies should therefore analyse differences in young players' positional variables when using various length: width ratios. Specifically, could coaches use a certain length: width ratio for SSGs in order to improve the players' positioning in matches?

Conclusion

In conclusion, the acute physical and technical responses of the young female players were relatively low compared to previous findings with males. The length: width ratio had very little effect on any physical or technical variable during SSGs regardless of player number (3v3 and 4v4). In fact, player number had the biggest effect on acute physical/technical responses and outputs with this group of players. The technical output overall was limited in variety, which is likely a reflection of the level of player used in this study. Additionally practitioners should be aware that the involvement in play was highly variable with some players having an inadequate number of individual possessions which could have implications for player development.

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APPENDICES

Appendix 1: Ethics approval
1

A U T E C
S E C R E T A R I A T

18 June 2014

Andrew Kilding
Faculty of Health and Environmental Sciences

Dear Andrew

Re Ethics Application: **14/137 The physical, technical and tactical effects of manipulating the playing area during football small sided games.**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 17 June 2017.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/researchethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 17 June 2017;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/researchethics. This report is to be submitted either when the approval expires on 17 June 2017 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Simon Tyndel styndel@hotmail.com

Appendix 2: Parent information sheet
2

20 May 2014

The physical, technical and tactical effects of manipulating the playing area during football small sided games

Hi, my name is Simon Tyndel and I would like to invite your child to participate in my post-graduate research at AUT University which aims to help coaches of young football players design/plan effective training sessions using small sided games.

Please read this information and decide whether or not you would like your child to be involved in the project. Your child does not have to be involved, and he/she can stop being involved in the project at any time without having to provide a reason. Participation in this project will not affect their place in the football team in any way.

What is the purpose of this research?

The use of small sided games (SSG) is currently very popular with many professional and amateur football teams worldwide. There is still a lot that we don't know about SSGs such as the most appropriate pitch size for optimal physical conditioning and technical development, especially in young players. The main aim is to determine the effect of changing the playing area size (length and width) on different movements in the game (such as frequency of high speed sprints, accelerations and changes of direction etc.), heart rate response and technical performance. This will be done by monitoring the players' physical and technical performance during a variety of SSGs (3v3, 4v4, 5v5, 7v7 etc.) played on different pitch sizes. This aims to help coaches to pick the most appropriate games to develop the team technically and physically.

The results of the study may also be published in scientific journals but your child will remain anonymous and their name will not appear in any papers seen by others.

How was my child identified and why is he/she being invited to participate in this research?

This research is targeting young male and female football players (13-18 years old). Several youth teams, currently training at least twice each week will be approached. Players will be recruited on a first-come basis. Those signalling an interest to participate once the study sample size has been reached will be given the opportunity to be added to a subject recruitment database for future football studies.

Any football player with injuries that impair running performance will not be asked to be part of the study. Football players with illness at the time of the study, either acute or chronic, will also be excluded.

Participants will need to attend the fitness testing sessions to be included in the study

What will happen in this research?

Your child will be required to attend an initial fitness testing session in which we will determine their maximum sprinting speed (MSS) and their maximal aerobic speed (MAS)

1. MSS: Your child will be required to sprint as fast they can between speed timing lights over a distance of 40m that will record their highest sprinting speed
2. MAS: Timed 1 mile run (1600m) 4 laps of Athletics track. Your child will be encouraged to push themselves and to run the 4 laps of the athletics track as fast as they can manage

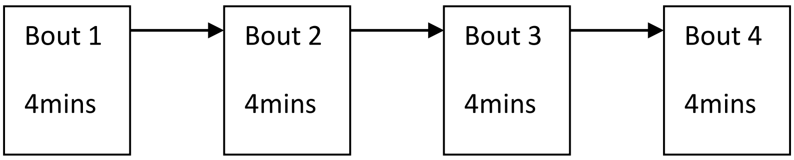
Thereafter, your child will take part in one SSG session per week for a total duration of 8-10 weeks. In discussion and negotiation with the head coach, we will try to integrate the sessions into current sessions that your child participates in. All SSG sessions will have a physical conditioning component to them to supplement the technical/tactical work that the players are already doing in their regular training sessions. SSG is the standard reference term for any game with smaller teams than 11v11 (i.e. 3v3, 5v5, 7v7, 8v8). Widely used by many football teams for physical conditioning and/or technical development.

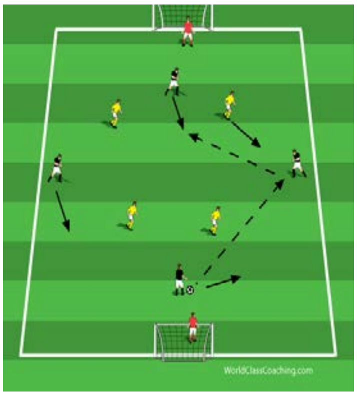
A typical SSG session (60 minutes) to be used during the study is illustrated below:

Dynamic warm-up – 15 minutes

SSG – 24 minutes: 4×4 minute SSG (e.g. 4v4) with 2 minute recovery

between each bout (i.e. 4×6 minute)





Injury prevention/functional strength circuit – 15 minutes

During all SSG sessions your child will be required to wear a heart rate monitor around their chest. The session will be video recorded to see how well they performed skills during the various SSGs. In addition, we will use state of the art player tracking technology (Catapult

Innovations, Melbourne, Australia) (http://www.catapultsports.com) which is now used by many of the professional sports teams in the world. The GPS unit is extremely lightweight and fits snugly between the shoulder blades when wearing the Catapult neoprene vest (see Fig 1 below)

Figure 1. Images of GPS units worn by players during team sports.

In the very unlikely event that we notice anything unusual in your child's heart rate measurements, we will bring this to your attention and advise to seek further medical attention.

What are the discomforts and risks?

There are no risks other than those football players typically experience during football training and matches such as contact and non-contact injuries. We will minimise the chance of injury by providing sufficient warm ups prior to testing and SSGs. There may be slight discomfort with wearing the heart rate monitors and GPS for the first time but participants will quickly get used to them and forget they are wearing them. Most top professionals clubs around the world wear similar equipment during their daily training sessions. They don't restrict movement or hinder the way individuals play during the training sessions and matches.

What are the benefits from this project?

1. Your child will get to know about their different fitness scores (power, speed, agility and endurance).
2. We are able to benchmark some of their fitness scores against data from the Football Ferns, Junior Football Ferns (U-20) and the Young Football Ferns (U-17)
3. Your child will know how much distance they run in a match and SSGs compared to elite professional players and other young female players from around the world
4. The technical analysis will tell your child how well they perform different football skills (passing, running-in, shooting, holding space, 1st touch-move etc.) during the small sided games.
5. By taking part in this project your child is helping us to help their coach plan his sessions in the most efficient way to help he/she become a better football player.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your child's participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my child's privacy be protected?

All individual data collected from training sessions, matches and fitness testing will be de-identified and shall remain confidential. Some of the data collected during this study may be published in a scientific paper on behalf of AUT (Auckland University of Technology), however all participants shall remain anonymous.

Video footage taken from the SSGs will be used in order to carry out a technical analysis of each individual player. The coach may request use of some of the video footage as a coaching aid to be used in team meetings in order to provide the team/individuals with visual feedback.

The video footage, training and testing data will not be shared with anyone apart from the team's coach (es) and the primary researcher (Simon Tyndel).

What are the costs of participating in this research?

None if possible. We will try to integrate the SSG and testing sessions into existing training sessions as best we can. Should this prove to be unfeasible, we may need to schedule one extra session of approximately 60 minutes (venue and date TBC) for the fitness testing. There will be no ongoing extra training commitments beyond the existing training sessions

What opportunity do I have to consider this invitation?

Please take your time to decide if you are happy for your child to participate in the project. If you are happy for them to participate, please fill in the parental consent form and return it to me alongside your child's assent form next week at the start of a training session.

Thank you for taking the time to read this information sheet.

Will I receive feedback on the results of this research?

All participants will receive feedback on their results from the initial fitness testing sessions alongside normative data from other population groups as a benchmark (elte professional players, elite youth players, semi-professional players, male and female players)

Data taken from the SSGs will be presented to the coach as group averages. Players will be able to request their individual results.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Associate Professor Andrew Kilding, Andrew.kilding@aut.ac.nz, Ph 921 999 ext. 7056

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz* , 921 9999 ext 6038.

Whom do I contact for further information about this research?

Researcher Contact Details:

Simon Tyndel, School of Sport and Recreation, AUT University, styndel@hotmail.com

Project Supervisor Contact Details:

Assoc. Prof. Andrew Kilding, SPRINZ, School of Sport and Recreation, AUT University, Private Bag 92006, Auckland 1020, Ph 921 9999 ext. 7056, Andrew.kilding@aut.ac.nz

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number*.