Physiology of Small-Sided Games Training in Football

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Franco M Impellizzeri
University of Technology Sydney

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Physiology of Small-Sided Games Training in Football

A Systematic Review

Stephen V. Hill-Haas,[1] *Brian Dawson,*[1] *Franco M. Impellizzeri*[2,3] and *Aaron J. Coutts*[4]

1 School of Sports Science, Exercise & Health, University of Western Australia, Perth, Western Australia, Australia
2 Neuromuscular Research Laboratory, Schulthess Clinic, FIFA Centre of Excellence, Zurich, Switzerland
3 Research Centre for Sport, Mountain and Health (CSMS) of Rovereto, University of Verona, Verona Italy
4 School of Leisure, Sport & Tourism, University of Technology, Lindfield, New South Wales, Australia

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Abstract

Small-sided games (SSGs) are played on reduced pitch areas, often using modified rules and involving a smaller number of players than traditional football. These games are less structured than traditional fitness training methods but are very popular training drills for players of all ages and levels. At present, there is relatively little information regarding how SSGs can best be used to improve physical capacities and technical or tactical skills in footballers. However, many prescriptive variables controlled by the coach can influence the exercise intensity during SSGs. Coaches usually attempt to change the training stimulus in SSGs through altering the pitch area, player number, coach encouragement, training regimen (continuous vs interval training), rules and the use of goalkeepers. In general, it appears that SSG exercise intensity is increased with the concurrent reduction in player number and increase in relative pitch area per player. However, the inverse relationship between the number of players in each SSG and exercise intensity does not apply to the time-motion characteristics. Consistent coach encouragement can also increase training intensity, but most rule changes do not appear to strongly affect exercise intensity. The variation of exercise intensity measures are lower in smaller game formats (e.g. three vs three) and have acceptable reproducibility when the same game is repeated between different training sessions or within the same session. The variation in exercise intensity during SSGs can also be improved with consistent coach encouragement but it is still more variable than traditional generic training methods. Other studies have also shown that SSGs containing fewer players can exceed match intensity and elicit similar intensities to both long- and short-duration high-intensity interval running. It also appears that fitness and football-specific performance can be improved equally with SSG and generic training drills. Future research is required to examine the optimal periodization strategies of SSGs training for the long-term development of physiological capacity, technical skill and tactical proficiency.

1. Introduction

The main purpose of this review is to provide a summary of the research that has examined the physiological and performance benefits of small-sided games (SSGs) in football. The review is presented in six sections. The first section briefly describes the origins, definition and advantages of SSGs. The second section reviews the use of SSGs in football. The three aspects addressed in the second section include findings from studies that have examined (i) the validity and reliability of quantifiable exercise intensity measures in SSGs; (ii) time-motion analysis of SSGs using Global Positioning System (GPS) technology; and (iii) variables affecting SSGs training intensity.

The third section contains two parts. Part A examines studies that describe the acute physiological responses associated with various SSGs and part B examines training studies that compare the effectiveness of using both interval and SSGs training for conditioning. The fourth section describes the limitations of SSGs as a fitness training mode. The final two sections provide suggestions for future research and conclude the review.

The articles reviewed here were acquired by searching the electronic databases of AUSPORT, ProQuest 5000, PubMed, SPORTDiscus® and Google Scholar. The following keywords were used in various combinations: 'small-sided soccer games', 'small-sided football games', 'metabolic conditioning', 'soccer-specific conditioning', 'football-specific conditioning', 'skill-based training', 'skill-based conditioning', 'soccer training', 'football training' and 'game-based training'. Due to the focus on football, this reduced the number of articles retrieved and, consequently, no limit to the search period was applied. Electronic database searching was supplemented by examining the bibliographies of relevant articles.

This review is justified, given the increasing amount of research conducted into SSGs in football. It represents a useful synthesis of all research into SSGs in football, and helps to identify areas for future research, including the investigation of the technical load and tactical transfer of SSGs to match performance. Finally, it serves to further establish SSGs training as an alternative conditioning method for football players.

2. Small-Sided Games (SSGs) in Football

SSGs, also referred to as skill-based conditioning games[1] or game-based training,[2] are modified games played on reduced pitch areas, often using adapted rules and involving a smaller number of players than traditional football games. Formalized SSGs, such as those implemented in football clubs throughout the world and which underpin many junior football development programmes (e.g. Royal Dutch Football Association, Football Federation Australia), appear to have evolved from informal unstructured games of street football. Indeed, many of the world's top players were introduced to football informally, via street, park or beach football.[3] Although it is still common to observe informal football SSGs being played in the street, park or beach, a structured approach to SSGs training has been adopted in the club setting.[3]

SSGs in football are widely considered to offer many practical advantages that have lead to its popularity as a training modality in football at all ages and levels. The primary benefits of SSGs are that they appear to replicate the movement demands, physiological intensity and technical requirements of competitive match play,[4-7] whilst also requiring players to make decisions under pressure and fatigue.[8] SSGs have also been suggested to facilitate the development of technical skills and tactical awareness within the appropriate context of a game.[7,9] Compared with traditional fitness training sessions, SSGs are thought to increase player compliance and motivation, since it is perceived to be sport specific.[6,7] Finally, SSGs are considered to be more time efficient, as physical performance, technical skills and tactical awareness, can be developed concurrently.[6,7] However, the realization of these advantages is dependent on game design.

2.1 Quantifying Exercise Intensity During SSGs

Exercise intensity in SSGs has typically been assessed via heart rate (HR), blood lactate concentration and rating of perceived exertion (RPE). Indeed, HR is the most common measure used for objectively monitoring training intensity in many sports,[10] and several studies have shown HR to be a valid indicator of exercise intensity in football.[11,12] For example, the mean HR and oxygen consumption ($\dot{V}O_2$) relationship have been reported to be similar during treadmill-based intermittent exercise that reproduced the demands of a football game.[11] Similarly, several studies have shown that the HR/$\dot{V}O_2$ relationship established in the laboratory is similar to the HR/$\dot{V}O_2$ relationship measured at different intensities during football-specific exercises (five vs five SSGs).[12-14] Collectively, the findings indicate that HR is a valid measure of exercise intensity during football.

There are, however, some limitations to using HR to assess exercise intensity during football-specific activities. For example, it has been suggested that factors inherent in football training, including emotion and the intermittent nature of the activity, may result in HR values that overestimate actual energetic cost of exercise.[15] In contrast, there is also evidence showing that HR monitoring may underestimate the intensity of football drills that have a high anaerobic component, including short-duration SSGs involving few players (e.g. 2-minute bouts; two vs two).[16] Therefore, it seems that other measures of exercise intensity may provide a more appropriate measure of exercise intensity during SSGs.

Blood lactate, a by-product of anaerobic glycolysis, has been extensively used as an indicator of exercise intensity in football. The blood lactate concentration has been suggested to represent an overall accumulation of lactate production during football-specific exercise.[17] However, given the intermittent nature of football, blood lactate concentration is a poor indicator of muscle lactate concentration during football match play[17] and, consequently, may be misrepresentative of individual exercise intensities.

In contrast to blood lactate concentration, RPE is a simple, non-invasive and inexpensive method of monitoring exercise intensity.[18] Several studies have shown that RPE can be validly used to assess exercise intensity at a specific time during exercise[19] and as a global indicator of overall session intensity (session RPE).[20,21] For example, to validate RPE as a measure of exercise intensity during football SSGs, Coutts et al.[19] examined the relationship between RPE with both HR and blood lactate concentration measures. The findings of this study demonstrated that the combination of HR and blood lactate concentration predicted RPE better than HR or blood lactate concentration measures alone. Therefore, it was suggested that RPE may be a more valid marker of global exercise intensity than any physiological measures independently.

Similarly, other studies have assessed the validity of the session RPE for assessing exercise intensity in football-specific exercise.[20,21] The session RPE method requires that players provide a single RPE relating to the exercise intensity of the entire session, usually 30 minutes following exercise.[22] However, although several studies have reported that session RPE is a valid indicator of overall perception of effort for intermittent aerobic football-specific exercises (including SSGs) training, it may not be a valid substitute for HR-based methods.[20,21] Nonetheless, due its psychobiological foundations,[18] session RPE measures may be a more valid global measure of exercise intensity during high-intensity intermittent exercise such as SSGs.

However, all the methods currently available to assess exercise intensity during SSGs do have limitations. There is no clear evidence to suggest that one particular method is superior to the others. The methodology chosen may depend on what the variable of interest is. Therefore, on the basis of studies examining the validity of HR, RPE and blood lactate concentration during football-specific training, it has been suggested that SSGs training is best monitored via a combination of each of these measures of internal exercise intensity.[19]

2.2 Time-Motion Measurement in SSGs

In addition to physiological measures of exercise intensity during SSGs, recent technological advances now allow for movement characteristics of football players to be collected.[23] This information may be used to design game-related conditioning activities.[23] Specifically, GPS microtechnology is now used by various professional football codes to quantify the movement demands on players during training and games.[23]

The validity and reliability of the measures provided by these commercially available (non-differential) GPS receivers has recently been described.[24-28] In general, the error for total distance travelled (metres/minute) has been reported to be between 3% and 5%.[24] Moreover, the correlations between speed measured by electronic timing gates and values obtained from GPS units, have also been reported to be very high.[25,29] However, there are several limitations associated with this technology, including reduced reliability with increased movement speeds.[24,28] For example, the coefficient of variation (CV) for high-intensity running (>14.4 km/h) is reported as 11.2–32.4%, and 11.5–30.4% for very high-intensity running (>20.0 km/h).[24] Moreover, lower sampling rates (i.e. 1 vs 5 Hz) may also be a limitation, as this may reduce the devices ability to detect changes in direction at high speed.[24,28] Other limitations, including the number of satellites available from which to collect data, as well as the inability to sample data indoors, should also be considered. However, despite these limitations, the information obtained from these devices, specifically measures of exercise intensity such as total distance, distance covered in wide speed zones (i.e. speed zones that include a wide range of velocities) and peak velocity, may still provide useful data regarding variations in movement demands in the various SSGs.

2.3 Variables Affecting SSG Intensity

The exercise intensity of SSGs can be demonstrated through a player's movement and/or physiological/perceptual responses. Many prescriptive variables that can be controlled by the coach may influence the exercise intensity during SSGs.[30] These factors include pitch area, player number, coach encouragement, training regimen (continuous or interval, including work : rest manipulations) rule modifications, and the use of goals and/or goalkeepers.[7,31] The following section will review how each of these factors have been manipulated to alter the exercise intensity during football SSGs.

Despite the recent increases in the number of research studies that have investigated the influence of adjusting each of these variables upon the exercise intensity in SSGs, caution should be applied when interpreting the practical suitability of a specific SSG on the basis of a statistical observation. It has been suggested that the small but significant changes in isolated physiological variables between the various SSG designs may have a relatively minor influence on training adaptation.[32] Nonetheless, it is possible that when an alteration in SSG design elicits changes in a combination of physiological variables together (e.g. blood lactate concentration and HR), that a vastly different training response may be elicited. Accordingly, because of these complex interactions, it is important that coaches and scientists carefully interpret changes in the physiological responses to various SSG designs in the context of the global response, rather than simply on the basis of a statistical assessment of single physiological variables.

2.3.1 Pitch Area

The total pitch area, both in absolute and relative terms, can be varied, and this may influence the intensity of SSGs. The relative pitch area per player is defined as the total pitch area divided by the total number of players. Table I is a summary of all the studies that examined the effect of manipulating absolute and relative pitch area (while keeping the number of players constant) on SSG intensity. The majority of studies report an increased HR, RPE and blood lactate concentration response with increased pitch area. For example, Rampinini et al.[32] increased the pitch area by 20% across a variety of SSG formats (three vs three to six vs six, inclusive). Both the percentage of maximum HR (%HR_{max}) and blood lactate concentration were higher during SSGs played on a large pitch than on a medium-sized or small pitch. RPE was also higher on medium and large pitch sizes compared with small pitches.[32]

2.3.2 Player Number

The number of players on each team in a SSG can also be altered to regulate the intensity of this training mode. Studies that have investigated the effect of altering player number on SSGs training intensity have altered player numbers while, at the same time, held many other factors constant, including the pitch area. A summary of all the studies that examined the effect of altering player numbers on SSG intensity is presented in table II.

In summary, despite some methodological concerns (very short game duration; differing work : rest ratios), most studies have shown that SSGs containing smaller numbers of players elicit greater HR, blood lactate and perceptual responses.[34,35,37,39] On closer analysis, the results suggest the possible existence of a threshold pitch area. For example, the most pronounced reductions in HR occurred when two versus two was increased to three versus three, and three versus three was increased to four versus four, on a 25×20 metre pitch area. In contrast, less pronounced reductions in HR occurred when two versus two was increased to three versus three, and three versus three was increased to four versus four on 20×15 metre and 30×25 metre pitch areas, respectively.[34]

As illustrated in table II, these previous studies only examined the influence of altering the player numbers on teams containing equal numbers of players (e.g. two vs two or three vs three). In training situations, SSGs are often implemented that contain teams of unequal numbers (e.g. four vs three players or six vs five). Reasons for creating an imbalance between opposing teams may include technical development and unavailability of players due to injury. A further variation in player number involves creating temporary ‘overload’ and ‘underload’ situations between opposing teams, via the use of a ‘floater’ player. This neutral player transitions to the team in possession of the ball, to create temporary ‘overload’ and ‘underload’ situations. This SSG game design is typically used to develop defensive or attacking proficiency or to increase the physical load on the ‘floating’ player.

The impact of creating fixed and temporary ‘overload’ and ‘underload’ situations (including the use of a ‘floater’) on the physiological, perceptual and time-motion responses in SSGs involving elite youth football players have recently been investigated.[38] The findings from this study

Table I. Summary of studies examining the effects of pitch dimensions on small-sided game intensity in football players

Study	Sample size	Game design	Training prescription	Pitch dimensions (m)	Area per player[a] (m^2)	$\%HR_{max}$ [mean ± SD][b]	[BLa^-] (mmol/L) [mean ± SD]	RPE (6–20 AU)[c] [mean ± SD]
Aroso et al.[33]	14	4 vs 4	3×6 min/90 s rest	30×20	75	70.0±9.0	2.6±1.7	13.3±0.9
				50×30	188	–	↑ (no value)	↑ (no value)
Owen et al.[34]	13	1 vs 1	1×3 min/12 min rest	10×5	25	86.0	–	–
				15×10	75	88.0	–	–
				20×15	150	89.0	–	–
		2 vs 2		15×10	38	84.2	–	–
				20×15	75	87.4	–	–
				25×20	125	88.1	–	–
		3 vs 3		20×15	50	81.7	–	–
				25×20	83	81.8	–	–
				30×25	125	84.8	–	–
		4 vs 4		25×20	63	72.0	–	–
				30×25	94	78.5	–	–
		5 vs 5		30×25	75	75.7	–	–
				35×30	105	79.5	–	–
				40×35	140	80.2	–	–
Williams and Owen[35]	9	3 vs 3	–	20×15	50	164±12[d] (mean HR)	–	–
				25×20	83	166±9[d] (mean HR)	–	–
				30×25	125	171±11[d] (mean HR)	–	–
Rampinini et al.[32]	20	3 vs 3 (CE)	3×4 min/3 min rest	20×12	40	89.5±2.9	6.0±1.8	8.1±0.6 (CR10)
				25×15	63	90.5±2.3	6.3±1.5	8.4±0.4 (CR10)
				30×18	90	90.9±2.0	6.5±1.5	8.5±0.4 (CR10)
		4 vs 4 (CE)		24×16	48	88.7±2.0	5.3±1.9	7.6±0.5 (CR10)
				30×20	75	89.4±1.8	5.5±1.8	7.9±0.5 (CR10)
				36×24	108	89.7± 1.8	6.0±1.6	8.1±0.5 (CR10)
		5 vs 5 (CE)		28×20	56	87.8±3.6	5.2±1.4	7.2±0.9 (CR10)
				35×25	88	88.8±3.1	5.0±1.7	7.6±0.6 (CR10)
				42×30	126	88.8±2.3	5.8±1.6	7.5±0.6 (CR10)
		6 vs 6 (CE)		32×24	64	86.4±2.0	4.5±1.5	6.8±0.6 (CR10)
				40×30	100	87.0±2.4	5.0±1.6	7.3±0.7 (CR10)
				48×36	144	86.9±2.4	4.8±1.5	7.2±0.8 (CR10)
Kelly and Drust[36]	8	5 vs 5 (CE)	4×4 min/2 min rest	30×20	60	91.0±4.0	–	–
				40×30	120	90.0±4.0	–	–
				50×40	200	89.0±2.0	–	–

a Total pitch area divided by total number of players.

b Data for Owen et al.[34] are presented as mean values.

c RPE is 6–20 AU unless otherwise stated.

d Age predicted HR values, mean ± SD.

AU = arbitrary units; **[BLa^-]** = blood lactate concentration; **CE** = with coach encouragement; **CR10** = category ratio 10 scale; **HR** = heart rate; **$\%HR_{max}$** = percentage of maximum HR; **RPE** = rating of perceived exertion; ↑ indicates increase; – indicates no data.

were that there were no significant differences between the fixed (four vs three or six vs five) and variable (three vs three + one floater or five vs five + one floater) SSGs in terms of physiological and perceptual responses (see table II). Despite this, either may provide a useful SSGs training variation, or as a technical/tactical training method for defensive, transition and attacking plays. The possibility of fixed and variable SSGs providing a greater technical load needs to be examined by further research. Finally, the use of a floater appears to be more effective in SSGs containing fewer players (e.g. three vs three + one floater), and may be appropriate for either maintaining or developing aerobic fitness.[38] For example, the floater travelled a significantly greater total distance and recorded a greater RPE compared with four-player teams in four- versus

Table II. Summary of studies examining the effects of player number on small-sided game intensity in football players

Study	Sample size	Game design	Training prescription	Pitch dimensions (m)	Area per player[a] (m^2)	$\%HR_{max}$ [mean ± SD]	[BLa⁻] (mmol/L) [mean ± SD]	RPE (6–20 AU)[b] [mean ± SD]
Aroso et al.[33]	14	2 vs 2	3×1.5 min/90 s rest	30×20	150	84.0 ± 5.0	8.1 ± 2.7	16.2 ± 1.1
		3 vs 3	3×4 min/90 s rest	30×20	100	87.0 ± 3.0	4.9 ± 2.0	14.5 ± 1.7
		4 vs 4	3×6 min/90 s rest	30×20	75	70.0 ± 9.0	2.6 ± 1.7	13.3 ± 0.9
Owen et al.[34]	13	1 vs 1	1×3 min/12 min rest	15×10	75	88.0[c]	–	–
		2 vs 2		15×10	38	84.2[c]	–	–
		1 vs 1		20×15	150	89.0[c]	–	–
		2 vs 2		20×15	75	87.4[c]	–	–
		3 vs 3		20×15	50	81.7[d]	–	–
		2 vs 2		25×20	125	88.1[c]	–	–
		3 vs 3		25×20	83	81.8[d]	–	–
		4 vs 4		25×20	63	72.0[e]	–	–
		4 vs 4		30×25	94	78.5[e]	–	–
		5 vs 5		30×25	75	75.7[e]	–	–
Sampaio et al.[37]	8	2 vs 2	2×1.5 min/90 s rest	30×20	150	83.7 ± 1.4	–	15.5 ± 0.6
		3 vs 3	2×3 min/90 s rest	30×20	100	80.8 ± 1.7	–	15.8 ± 0.2
Williams and Owen[35]	9	1 vs 1	–	20×15	150	183 ± 7 (mean HR)	–	–
		2 vs 2	–	20×15	75	179 ± 7 (mean HR)	–	–
		3 vs 3	–	20×15	50	164 ± 12 (mean HR)	–	–
		2 vs 2	–	25×20	125	180 ± 5 (mean HR)	–	–
		3 vs 3	–	25×20	83	166 ± 9 (mean HR)	–	–
		4 vs 4	–	25×20	63	152 ± 14 (mean HR)	–	–
		3 vs 3	–	30×25	125	171 ± 11 (mean HR)	–	–
		4 vs 4	–	30×25	94	165 ± 5 (mean HR)	–	–
		5 vs 5	–	30×25	75	152 ± 6 (mean HR)	–	–
Hill-Haas et al.[38]	12	3 players	24[f]	37×28	148	82.3 ± 3.5 2543 ± 187 (TD m)	2.5 ± 0.7 553 ± 187 (D m)	16.3 ± 1.6 10 ± 6 (SP)
	16	4 players	24[f]	37×28	148	83.1 ± 4.0 2408 ± 231 (TD m)	2.5 ± 0.9 482 ± 178 (D m)	14.6 ± 1.9 8 ± 4 (SP)
	8	Floater	24[f]	37×28	148	82.7 ± 3.0 2668 ± 220 (TD m)	2.3 ± 0.8 628 ± 132 (D m)	16.3 ± 1.5 9 ± 6 (SP)
	20	5 players	24[f]	47×35	149	82.5 ± 5.0 2526 ± 302 (TD m)	2.5 ± 1.0 649 ± 190 (D m)	15.2 ± 1.0 9 ± 5 (SP)
	24	6 players	24[f]	47×35	149	81.4 ± 5.1 2524 ± 247 (TD m)	2.6 ± 1.1 589 ± 177 (D m)	14.9 ± 0.9 8 ± 4 (SP)
	4	Floater	24[f]	47×35	149	82.5 ± 5.6 2610 ± 201 (TD m)	2.8 ± 0.2 673 ± 194 (D m)	16.3 ± 1.7 15 ± 3 (SP)

Continued next page

Table II. Contd

Study	Sample size	Game design	Training prescription	Pitch dimensions (m)	Area per player[a] (m^2)	$\%HR_{max}$ [mean ± SD]	[BLa^-] (mmol/L) [mean ± SD]	RPE (6–20 AU)[b] [mean ± SD]
	Matched PN[g]	3 vs 3 and				82.5 ± 4.6	2.6 ± 1.1	15.2 ± 1.4
		5 vs 5				2585 ± 204 (TD m)	582 ± 190 (D m)	–
	Overload PN	6 player and				82.3 ± 4.5	2.6 ± 1.0	14.7 ± 1.5
		4 player teams				2458 ± 243 (TD m)	528 ± 184 (D m)	–
	Underload PN	5 player and				82.3 ± 4.0	2.6 ± 1.0	15.8 ± 1.5
		3 player teams				2535 ± 247 (TD m)	598 ± 192 (D m)	–

a Total pitch area divided by total number of players.

b RPE is 6–20 AU unless otherwise stated.

c intensity >11 vs 11 competitive match.

d intensity = 11 vs 11 competitive match.

e intensity <11 vs 11 competitive match.

f Game duration (min).

g Matched team excluding the floater.

AU = arbitrary units; **[BLa^-]** = blood lactate concentration; **D** = distance (m): >13.0 km/h; **HR** = heart rate; **$\%HR_{max}$** = percentage of maximum HR; **PN** = player numbers; **RPE** = rating of perceived exertion; **SP** = number of sprints >18.0 km/h; **TD** = total distance (m); – indicates no data.

three-player games[38] (figure 1). The floater also completed a significantly greater amount of sprints (>18 km/h) compared with five- and six-player teams in six- versus five-player games[38] (see table II).

2.3.3 Concurrent Manipulation of Pitch Area and Player Number

Few studies have systematically examined the influence of the concurrent manipulation of pitch area and player number on exercise intensity in SSGs.[32,40-42] In addition, there are several differences in the design and prescription of the SSGs in the studies that inadvertently manipulated both player number and pitch area, making comparisons between these studies very difficult. Indeed, tables III and IV show that there are subtle differences in the training prescriptions, age and ability of players, intensity measures and sizes in pitch area amongst the studies, all of which may affect the exercise intensity in these SSGs.

In general, it appears that a concurrent increase in player number and relative pitch area per player in SSGs elicits lower exercise intensity. For example, Rampinini et al.[32] investigated the effects of concurrently increasing the player number and pitch area on $\%HR_{max}$, blood lactate concentration and RPE in 20 amateur football players. The main finding of this study was that the exercise intensity during all game formats was decreased when there was an increase in the number of players and more pitch area per player[32] (see table III). Similarly, Jones and Drust[41] also reported a reduction in $\%HR_{max}$ when both player number and pitch area were increased (see table III).

One important aspect that has not been considered by studies where both pitch size and player number were altered concurrently was the influence of the relative pitch area per player.[16,32,41-44] In all of these studies, an increase in absolute pitch area and player number also resulted in a greater relative pitch area per player. Therefore, the observed reduction in SSG intensity by several of these studies[32,41,42] may have been due to either the independent effects of increasing the number of players or the inability of the additional players to cover more of the available pitch area. Clearly, more research is required to determine the effect of an increase in player number on

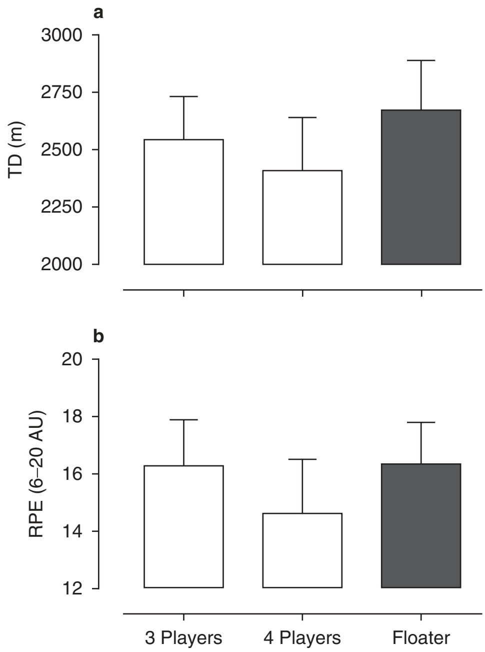

Fig. 1. Comparison of (**a**) total distance (TD; m) and (**b**) rating of perceived exertion (RPE) [6–20 arbitrary units; AU] with 'floating' players and other players in various smaller game formats.[38]

SSG intensity (or *vice versa*). However, it is important that future studies control for the influence of relative pitch area per player so that an improved understanding of increasing pitch area and player number in SSGs can be obtained.

More recently, a study involving youth football players examined the acute physiological and perceptual responses and time-motion characteristics during three variations of SSGs (two vs two, four vs four and six vs six) with a constant ratio of player number to pitch area applied to each SSG variation.[45] The main findings were, as the number of players in the SSG teams decreased, when the relative pitch area per player remained constant, the overall physiological and perceptual responses increased. Notably, the inverse relationship between the number of players in each SSG and exercise intensity did not extend to the time-motion characteristics. In general, the largest game format (six vs six) was associated with a greater range of distances travelled at speeds >18 km/h. In contrast, the four versus four format, compared with the two versus two, was characterized by significantly longer (average and maximal) effort durations and distances for speeds >18 km/h.[45] However, since it is the internal response to training (e.g. HR and RPE) and not the external training load (e.g. distances travelled in speed zones) that determines each players adaptation to a training stimulus,[46] it is recommended that each player's internal load be monitored to assess how players are coping with different SSGs design (see table IV).

2.3.4 Rule Modifications

In practice, football coaches quite often modify playing rules in SSGs to achieve greater exercise intensity, or develop specific technical and tactical skills. However, there have only been a few studies that have examined how the modification of rules can influence these variables. Table V provides a summary of studies that have investigated the effects of rule changes on exercise intensity during football SSGs. Two studies[47,48] reported an increase in $\%HR_{max}$ and another reported an increase in blood lactate concentration due to rule changes[33] (table V). Simple rule changes have also been reported to increase the perception of effort[37] (table V), which may be due to the increased cognitive load required of players as a consequence of new rules. To date, the only study to have reported on the influence of rule changes on movement characteristics is by Mallo and Navarro.[48] Compared with normal football rules, these specific rule changes resulted in an increase in total distance travelled (table V) and time spent performing high-intensity running, with less spent time spent stationary.[33,48]

Although these simple rule modifications relate to technical aspects of the game, other studies have investigated the influence of providing 'artificial' changes.[38] An example of an artificial rule change is the requirement for a player to complete a series of sprints of planned duration during a SSG. Hill-Haas et al.[38] recently examined the acute physiological responses and time-motion characteristics associated with four different rule changes, including the addition of 'artificial' rules. The main finding was that changes in SSG playing rules can influence the physiological and time-motion responses, but not

Table III. Summary of studies examining the effects of concurrent changes in player number and pitch dimensions on small-sided game intensity in football players

Study	Sample size; age (y)	Game design	Training prescription	Pitch dimensions (m)	Area per player[a] (m^2)	$\%HR_{max}$ [mean ± SD][b]	[BLa^-] (mmol/L) [mean ± SD]	RPE (6–20 AU)[c] [mean ± SD]
Platt et al.[43]	2; 10–12	3 vs 3	1 × 15 min continuous	27 × 18	81	88.0[d]	–	–
		5 vs 5	1 × 15 min continuous	37 × 27	100	82.0[d]	–	–
Little and Williams[16]	28; NR	2 vs 2	4 × 2 min/2 min rest	27 × 18	122	88.9 ± 1.2	9.6 ± 1.0	16.3 ± 0.9
		3 vs 3	4 × 3.5 min/90 s rest	32 × 23	123	91.0 ± 1.2	8.5 ± 0.8	15.7 ± 1.1
		4 vs 4	4 × 4 min/2 min rest	37 × 27	125	90.1 ± 1.5	9.5 ± 1.1	15.3 ± 0.7
		5 vs 5	4 × 6 min/90 s rest	41 × 27	111	89.3 ± 2.5	7.9 ± 1.7	14.3 ± 1.5
		6 vs 6	3 × 8 min/90 s rest	46 × 27	104	87.5 ± 2.0	5.6 ± 1.9	13.6 ± 1.0
		8 vs 8	4 × 8 min/90 s rest	73 × 41	187	87.9 ± 1.9	5.8 ± 2.1	14.1 ± 1.8
Jones and Drust[41]	8; 7	4 vs 4	1 × 10 min continuous	30 × 25	94	83.0	–	–
		8 vs 8	1 × 10 min continuous	60 × 40	150	79.0	–	–
Rampinini et al.[32]	20; NR	3 vs 3 (CE)	3 × 4 min/3 min rest	30 × 18	90	90.9 ± 2.0	6.5 ± 1.5	8.5 ± 0.4 (CR10)
		4 vs 4 (CE)		36 × 24	108	89.7 ± 1.8	6.0 ± 1.6	8.1 ± 0.5 (CR10)
		5 vs 5 (CE)		42 × 30	126	88.8 ± 2.3	5.8 ± 1.6	7.5 ± 0.6 (CR10)
		6 vs 6 (CE)		48 × 36	144	86.9 ± 2.4	4.8 ± 1.5	7.2 ± 0.8 (CR10)

a Total pitch area divided by total number of players.

b Data for Platt et al.[43] and Jones and Drust[41] are presented as mean values.

c RPE is 6–20 AU unless otherwise stated.

d Age predicted heart rate values.

AU = arbitrary units; **[BLa^-]** = blood lactate concentration; **CE** = coach encouragement; **CR10** = category ratio 10 scale; **$\%HR_{max}$** = percentage of maximum heart rate; **NR** = not reported; **RPE** = rating of perceived exertion; – no data.

perceptual responses, in young elite football players (table V).[38] The artificial rule change that required players to complete extra sprint efforts around the pitch during each SSG at pre-set times, imposed a greater external training load on the players, but did not affect HR, blood lactate concentration or RPE. In contrast, changes in technical rules that were related to a team's chances of scoring, may have improved player motivation and thereby increased the exercise intensity during the SSGs.[38] Although there have been relatively few studies that have examined the influence of rule modifications on exercise intensity during SSGs, the rule changes that have been investigated are by no means exhaustive. To date, the rule changes that have been investigated have altered either the physiological and/or perceptual responses, as well as the time-motion characteristics of various SSGs. However, this may not be the case for all types of rule changes that could possibly be implemented. Future studies should aim to more systematically classify the types of rules changes that appear to have differential effects on physiological, perceptual and time-motion responses during SSGs. Future studies should examine the effect of common rules modifications on the technical and tactical skills of football players. Factors such as decision making and cognitive load of players should also be assessed (table V).

2.3.5 Goalkeepers

One common rule modification in SSGs is the removal of goalkeepers from the game in an attempt to increase the number of goals scored. Goalkeepers are an integral part of football; however, surprisingly few studies have investigated the use of goalkeepers and their possible effect on SSGs training intensity. Table VI provides a summary of the SSGs studies that investigated the effects of goalkeepers on SSG intensity. Mallo and Navarro[48] reported a significant decrease in $\%HR_{max}$, total distance and time spent in high-intensity running, in three versus three SSGs with goalkeepers. It was suggested that the reduced physiological and time-motion responses were due to increased defensive organization near the goal area, which reduced the tempo of play and subsequently the physiological and time-motion responses.[48] In contrast, Dellal et al.[44] reported a 12% increase in heart rate response in eight versus eight SSGs with goalkeepers. The presence of goalkeepers may have increased the player's motivation to both attack and defend, thereby increasing the physiological load.[44] At present, the influence of goalkeepers on exercise intensity in football SSGs is not clear. They may have an important role in keeping team structures and formations intact, as well as increasing communication, all of which may influence movement, skill and physiological demands. Future studies are required to determine the influence of goal keepers on the physiological and technical/tactical demands in SSGs.

2.3.6 Training Regimen (Including Game Duration and Work : Rest Ratios)

Similar to interval running, many prescriptive variables can be used in SSGs to alter exercise intensity. The majority of the studies have used a traditional 'interval' training format, whereby several consecutive bouts of SSGs play are interspersed with active or passive rest periods (table VII). The duration of each SSG bout interval, alternating with planned rest periods, is used to determine work : rest ratios. Although most studies examining SSGs have prescribed the SSG bouts using intervals with short rests, some recent studies have used continuous SSG formats of differing duration (e.g. 10–30 minutes).

Unfortunately, previous studies have not used consistent work : rest ratios and there is a large variation in the length, duration, and number of work bouts and rest intervals amongst studies (table VII), which makes comparison difficult. For example, a SSG 'interval' training prescription consisting of a 1×3-minute work bout with a 12-minute rest represents a very low work : rest ratio (1 : 4) and a very short total game duration

Table IV. Summary of studies examining the effects of concurrent changes in player number and pitch dimensions on small-sided game intensity in football players

Study	Sample size; age (y)	Game design	Training prescription	Pitch dimensions (m)	Area per player[a] (m^2)	%HRR [mean ± SD]	[BLa^-] (mmol/L) [mean ± SD]	RPE (6–20 AU)[b] [mean ± SD]
Dellal et al.[44]	10; 24–27[c]	1 vs 1	4×1.5 min/90 s rest	10×10	50	77.6±8.6	–	–
		2 vs 2	6×2.5 min/2.5 min rest	20×20	100	80.1±8.7	–	–
		4 vs 4+GK	2×4 min/3 min rest	30×25	94	77.1±10.7	–	–
		8 vs 8+GK	2×10 min/5 min rest	60×45	169	80.3±12.5	–	–
		8 vs 8	4×4 min/3 min rest	60×45	169	71.7±6.3	–	–
		10 vs 10+GK	3×20 min/5 min rest	90×45	203	75.7±7.9	–	–
Hill-Haas et al.[45]	16; 16–18[c]	2 vs 2	24 min continuous	28×21	150	89.0±4.0 (%HR_{max})[d]	6.7±2.6	13.1±1.5
						2574±16 TD (m)	1176±8 (D m)	44±24 (SP m)
		4 vs 4		40×30	150	85.0±4.0 (%HR_{max})[d]	4.7±1.6	12.2±1.8
						2650±18 TD (m)	1128±10 (D m)	65±36 (SP m)
		6 vs 6		49×37	150	83.0±4.0 (%HR_{max})[d]	4.1±2.0	10.5±1.5
						2590±33 TD (m)	1142±16 (D m)	71±36 (SP m)
Katis and Kellis[42]	34; 13±0.9[e]	3 vs 3	10×4 min/3 min rest	25×15	63	87.6±4.8	–	–
		6 vs 6		40×30	100	82.8±3.2	–	–

a Total pitch area divided by total number of players.

b RPE is 6–20 AU unless otherwise stated.

c Age range.

d Age predicted heart rate values.

e Age presented as mean ± SD.

AU = arbitrary units; **[BLa^-]** = blood lactate concentration; **D** = distance: 13.0–15.9 km/h; **GK** = including goalkeepers; **%HR_{max}** = percentage of maximum heart rate; **%HRR** = percentage of heart rate reserve; **RPE** = rating of perceived exertion; **SP** = number of sprints >18.0 km/h; **TD** = total distance; – indicates no data.

Table V. Summary of studies examining the effects of rule modifications on small-sided game intensity in football players

Study	Sample size	Game design	Training prescription	Pitch dimensions (m)	Rules	$\%HR_{max}$ [mean ± SD][a]	[BLa^-] (mmol/L) [mean ± SD]	RPE (6–20 AU) [mean ± SD]	TD (m) [mean ± SD]
Aroso et al.[33]	14	2 vs 2	3×1.5 min/90 s rest	30×20	Player-to-player marking	–	↑ 8.1 ± 2.7	–	–
		3 vs 3	3×4 min/90 s rest		Maximum of 3 consecutive touches	–	4.9 ± 2.0	–	–
Sassi et al.[47]	9	8 vs 8 + GK	4×4 min/2.5 min rest	50×30	Free touch	82.0	3.3 ± 1.2	–	–
		8 vs 8 + GK			Free touch with pressure	↑ 91.0	–	–	–
Sampaio et al.[37]	8	2 vs 2	2×1.5 min/90 s rest	30×20	Player-to-player marking	↔	–	↑ 17.1 ± 0.5	–
					Maximum of 2 consecutive touches	↔	–	↑ 16.8 ± 0.5	–
		3 vs 3	2×3 min/90 s rest		Player-to-player marking	↔	–	↑ 16.5 ± 0.5	–
					Maximum of 2 consecutive touches	↔	–	↑ 16.5 ± 0.5	–
Little and Williams[40]	23	5 vs 5	5×2 min/2 min rest	55×32	Pressure half switch	89.9	–	–	–
		6 vs 6	5×2 min/2 min rest	59×27	Pressure half switch	90.5	–	–	–
Mallo and Navarro[48]	10	3 vs 3	1×5 min/10 min rest	33×20	Possession	91.0 ↔	–	–	747 ± 24
					Possession with 2 outside neutral players	91.0 ↔	–	–	749 ± 29
					Normal rules + GK	88.0 ↓	–	–	638 ± 34
Hill-Haas et al.[38]	24	3 vs 4 and 3 vs 3 + 1 floater	24 min continuous	37×28	Condition a[b] + b[c]	83.3 ± 3.8	2.8 ± 1.0	15.8 ± 1.6	2439 ± 166
	23				Condition a + b + c[d]	84.8 ± 3.8	2.4 ± 0.8	15.6 ± 2.3	2405 ± 201
	23				Condition a + b + c + d[e]	80.3 ± 4.8	2.3 ± 1.1	14.8 ± 1.2	2450 ± 223
	26				Condition a + b + c + d + e[f]	83.7 ± 4.0	2.8 ± 1.1	15.1 ± 1.6	2677 ± 192
	21	5 v 6 and 5 v 5 + 1 floater	24 min continuous	47×35	Condition a[b] + b[c]	81 ± 4	2.2 ± 1.0	15.3 ± 1.1	2471 ± 355
	22				Condition a + b + c[d]	83 ± 5	3.2 ± 1.2	14.9 ± 1.4	2583 ± 147
	20				Condition a + b + c + d[e]	83 ± 5	2.3 ± 1.1	14.6 ± 0.9	2614 ± 178
	21				Condition a + b + c + d + e[f]	80 ± 3	2.4 ± 0.9	14.9 ± 1.1	2639 ± 189

a Data for Sassi et al.,[47] Little and Williams[40] and Mallo and Navarro[48] are presented as mean values.

b Condition a: offside rule in effect (front one-third zone of the pitch).

c Condition b: kick-in only (ball cannot be thrown in if it leaves the pitch).

d Condition c: all attacking team players must be in front two zones for a goal to count.

e Condition d: outside, but along the two lengths of each pitch, two neutral players can move up and down the pitch, but not enter the grid. Before a shot on goal is permitted, the attacking team must pass the ball to either of these players. The ball can also be passed to either player in the defensive half. Each player is only allowed a maximum of one touch on the ball.

f Condition e: one player from each team (a pair) complete four repetitions of 'sprint the widths/jog the lengths' on a 90 s interval (3 vs 4 and 3 vs 3 + 1 games) or three repetitions on a 80 s interval (5 vs 6 and 5 vs 5 + 1 games). TD travelled per player, regardless of game format, would be approximately 440 m.

AU = arbitrary units; **[BLa^-]** = blood lactate concentration; **GK** = including goalkeepers; **$\%HR_{max}$** = percentage of maximum heart rate; **RPE** = rating of perceived exertion; **TD** = total distance; ↑ indicates increase; ↓ indicates decrease; ↔ indicates no change; – indicates no data.

(3 minutes). Other studies have used different work: rest ratios across various SSGs (table VII).[16] Together, these may confound the physiological and perceptual responses, as well as the time-motion characteristics of the games. A recent study involving youth football players examined the acute physiological and perceptual responses and time-motion characteristics of two different training regimens (continuous and intermittent). These intermittent (4×6-minute bouts with 1.5 minutes passive rest) and continuous (24 minutes) regimens were applied to various SSGs including two versus two, four versus four and six versus six.[49] The main finding of this study was that intermittent regimens were characterized by increased distances covered at speeds of >13 km/h. However, paradoxically, the global RPE and $\%HR_{max}$ was significantly higher in continuous regimens. The results of this study demonstrated that both SSG training regimens could be used during a season for match-specific aerobic conditioning, but were unlikely to provide a sufficient stimulus overload for fully developing maximal oxygen consumption ($\dot{V}O_{2max}$).[49] Another study recently investigated the effect of SSG duration, using a 2-, 4- and 6-minute interval format, on both exercise intensity and technical performance during three versus three SSGs.[50] The main findings were that although there was a significant decrease in HR between the 4- and 6-minute game durations and an increase in RPE, the 4-minute bouts appear to provide the optimal physical training stimulus for interval format SSGs.[50] However, the various interval durations did not affect technical performance and, given that the magnitude of changes between each of the different interval bouts was small, football coaches can be confident in using various SSG interval durations to provide an adequate physical and technical training stimulus.[50] In summary, research shows that neither training regimen appears to offer any major advantage over the other, and that both regimens could be used for in-season aerobic fitness maintenance training.

2.3.7 Coach Encouragement

Direct supervision and coaching of exercise sessions have been shown to improve adherence to an exercise programme, increase training intensity and increase performance measures in a variety of training modes.[51,52] In football, active, consistent coach encouragement has also been suggested to have an influence on training intensity.[30,32,37] For example, Rampinini et al.[32] demonstrated that HR, blood lactate concentration and RPE were higher when coaches provided consistent encouragement during SSGs with 20 amateur football players in a variety of SSG formats (three vs three, four vs four, five vs five and six vs six players and on small, medium and large-sized pitches). Similarly,

Table VI. Summary of studies examining the effects of goalkeepers on small-sided game intensity in football players

Study	Sample size	Game design	Training prescription	Pitch dimensions (m)	Rules	$\%HR_{max}$[a] [mean ± SD][b]	[BLa⁻] (mmol/L) [mean ± SD]	Time motion
Sassi et al.[47]	9	4 vs 4	4×4 min/2.5 min rest	30×30	Possession	91.0	6.4 ± 2.7	–
		4 vs 4 + GK		33×33		↓ 88.8	6.2 ± 1.4	–
Mallo and Navarro[48]	10	3 vs 3 + GK	1×5 min/10 min rest	33×20	Normal rules	88.0 ↓	–	↓TD; ↓HIR; ↑S + W
Dellal et al.[44]	10	8 vs 8	4×4 min/3 min rest	60×45	–	71.7 ± 6.3 (%HRR)	–	–
		8 vs 8 + GK	2×10 min/5 min rest	60×45	–	↑ 80.3 ± 12.5 (%HRR)	–	–

a $\%HR_{max}$ unless otherwise stated.

b Data for Sassi et al.[47] and Mallo and Navarro[48] are presented as mean values.

[BLa⁻] = blood lactate concentration; **GK** = including goalkeepers; **HIR** = high-intensity running; **$\%HR_{max}$** = percentage of maximum heart rate; **%HRR** = percentage of heart rate reserve; **S + W**: standing and walking; **TD** = total distance; ↑ indicates increase; ↓ indicates decrease; – indicates no data.

Table VII. Summary of different training regimens implemented in small-sided game studies with football players

Study	Sample size	Game design	Training prescription	Work : rest ratio	Regimen
Balsom et al.[30]	6	3 vs 3	6×3 min/2 min rest	1.5 : 1	Interval
			15×70 s/20 s rest	3.5 : 1	Interval
			36×30 s/15 s rest	2 : 1	Interval
			36×30 s/30 s rest	1 : 1	Interval
			1×30 min	–	Continuous
Owen et al.[34]	13	1 vs 1 → 5 vs 5	1×3 min/12 min rest	1 : 4	Interval
Aroso et al.[33]	14	2 vs 2	3×1.5 min/90 s rest	1 : 1	Interval
		3 vs 3	3×4 min/90 s rest	2.6 : 1	Interval
		4 vs 4	3×6 min/90 s rest	4 : 1	Interval
Jones and Drust[41]	–	4 vs 4 and 8 vs 8	1×10 min	–	Continuous
Rampinini et al.[32]	20	3 vs 3 → 5 vs 5	3×4 min/3 min rest	1.3 : 1	Interval
Kelly and Drust[36]	8	5 vs 5	4×4 min/2 min rest	2 : 1	Interval
Little and Williams[16]	28	2 vs 2	4×2 min/2 min rest	1 : 1	Interval
		3 vs 3	4×3.5 min/90 s rest	2.3 : 1	Interval
		4 vs 4	4×4 min/2 min rest	2 : 1	Interval
		5 vs 5	4×6 min/90 s rest	4 : 1	Interval
		6 vs 6	3×8 min/90 s rest	5.3 : 1	Interval
		8 vs 8	4×8 min/90 s rest	5.3 : 1	Interval
Dellal et al.[44]	10	1 vs 1	4×1.5 min/90 s rest	1 : 1	Interval
		2 vs 2	6×2.5 min/2.5 min rest	1 : 1	Interval
		4 vs 4+GK	2×4 min/3 min rest	1.3 : 1	Interval
		8 vs 8+GK	2×10 min/5 min rest	2 : 1	Interval
		8vs 8	4×4 min/3 min rest	1.3 : 1	Interval
		10 vs 10+GK	3×20 min/5 min rest	4 : 1	Interval
Hill-Haas et al.[49]	16	2 vs 2; 4 v 4; 6 vs 6	4×6 min/90 s passive rest	4 : 1	Interval
		2 vs 2; 4 vs 4; 6 vs 6	1×24 min	–	Continuous
Fanchini et al.[50]	19	3 vs 3	3×2 min; 3×4 min; 3×6 min/4 min rest	1 : 2; 1 : 1; 1.5 : 1	Interval

GK = including goalkeepers; → indicates 1 vs 1, 2 vs 2, 3 vs 3, 4 vs 4 and 5 vs 5 small-sided games were used; – indicates no data.

Sampaio et al.[37] reported a significant increase in RPE (for two vs two and three vs three SSGs) with verbal encouragement, but no significant change in $\%HR_{max}$. Collectively, these studies support the role of the coach in providing consistent encouragement during SSGs, especially when it is planned that high intensities be achieved.

2.3.8 Logistics and Planning

The logistical considerations associated with organizing SSGs training are also important considerations for coaches, as these have the potential to influence player motivation and exercise intensity. For example, the total number of players available (including goalkeepers) to participate in any session will determine the number of SSG teams that can be formed, as well as the type of games implemented, particularly if the objective is to use evenly balanced teams.[7] In practice, coaches often like to create ‘competitive playing structures’, which typically require all SSG teams in one session to play against each other for an equal number of times. This type of playing structure is thought to increase motivation levels by increasing competition and placing an emphasis on results; however, this has not yet been empirically tested. It is possible that overuse of a competitive playing structure may result in the selection of an inappropriate training regimen and therefore a suboptimal training stimulus. If this occurs frequently, it may compromise longer term training adaptations. Therefore, it is suggested that coaches should select SSGs judiciously. They should also be aware that not all SSG formats will provide sufficient internal stress to provide the desired physiological adaptation.

Careful planning and organization of training sessions for SSGs is also important if the appropriate training stimulus is to be achieved. For example, factors such as planning SSGs according to a prospective training plan designed to meet the physical, technical and tactical requirements of the team, along with the appropriate use of coach encouragement, pitch area, player number, goalkeepers, rule modification and selection of work and rest periods, will help achieve optimal exercise intensity. The variation in individual responses to the various SSG structures within a session and between training sessions should also be considered.[32,53,54] Finally, it is advisable to avoid skill and fitness mismatches between opposing teams in order to avoid compromising training intensity.

2.3.9 Comparisons of SSG Training Intensity with Competitive Match Play

Several studies have examined how the exercise intensity of various SSGs compares with the exercise intensity of competitive match play.[8,44,55,56] The findings of these studies can also be used to determine if the most intense periods of matches compare with the intensity of various SSGs. For example, Gabbett and Mulvey[8] recruited 13 elite female football players and compared three versus three and five versus five SSGs with (i) domestic football matches against male youth teams; (ii) Australian National Women's League football matches; and (iii) international women's football matches. The main finding was that although SSGs simulate the overall movement patterns of domestic, national and international competition, they do not simulate the high-intensity repeated-sprint demands of international competition.[8] In contrast, Allen et al.[55] reported that although total distance was similar, the ratio of high- to low/moderate-intensity work in five versus five SSGs was higher compared with 11 versus 11 games. Similarly, the intensity of two versus two was found to exceed the intensity of State Premier League under 19 matches, while four versus four were similar to, and six versus six were below match intensity (figure 2). Capranica et al.[56] reported that the physiological intensity and movement demands of seven versus seven and 11 versus 11 in prepubescent football players were similar, with HRs exceeding

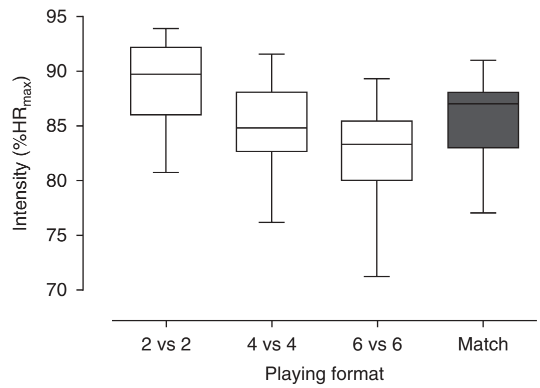

Fig. 2. Box and whisker plot of exercise intensity (percentage of maximum heart rate [%HR$_{max}$]) in various small-sided games and matches.[45]

170 beats per minute. In summary, it appears that selected SSG formats containing fewer players can exceed mean match intensity in youth football players. Coaches can use this information for choosing SSGs that are either more intense than match demands to overload the players, or lower than 11 versus 11 match intensity when either technical/tactical requirements or recovery and regeneration is the goal of training.

3. Studies Comparing SSGs Training with Interval Training

Despite the widespread use of SSGs in football, there are surprisingly few studies comparing their effectiveness in comparison to traditional forms of fitness training. The previous studies that have been completed can be divided into the following two categories: (i) studies that investigated acute physiological responses of SSGs and compared these with generic (interval) training responses;[30,44,47] and (ii) studies involving the comparison of each training mode on either physiological performance measures and/or direct match performance.[57-59]

3.1 Acute Physiological Comparisons of SSGs Training with Interval Training

Several studies have compared the physiological responses between generic interval training with football-specific SSG training drills. Indeed, many studies have shown that the exercise intensity achieved during SSGs are similar to generic fitness training drills of similar duration.[30,44,47] For example, Sassi et al.[47] compared the acute physiological responses of two formats of four versus four and eight versus eight SSGs with interval running (4×1000 metre repeats, separated by 150 seconds of recovery), using 11 elite professional players from a Spanish first division football club. Although there was no systematic manipulation of pitch area, game format (player number) or rule modifications in this study, the SSG formats elicited a greater %HR_{max} response compared with the interval running (91% vs 85% HR_{max}).[47] More recently, Dellal et al.[44] compared the HR response of short-duration (5- to 30-second efforts) high-intensity interval running with a variety of SSG formats, using ten elite footballers from a French first division football club. In contrast to the previous studies, only the two versus two (no goalkeepers) and eight versus eight (including goalkeepers) SSG formats generated similar HR responses compared with the short-duration interval running protocols. The one versus one (no goalkeepers) and four versus four (including goalkeepers) formats generated the lowest HR responses of both the SSGs and interval running.[44] In general, the results of these studies demonstrated that many smaller-format SSGs played on a relatively large pitch area per player, can elicit similar intensities to both long-duration interval running[47] and short-duration high-intensity interval protocols.[44] However, it appears that the variability in exercise stimulus is greater in SSGs compared with generic interval training (figure 3), which may be due to the unstructured and stochastic nature of the movement demands in SSGs.

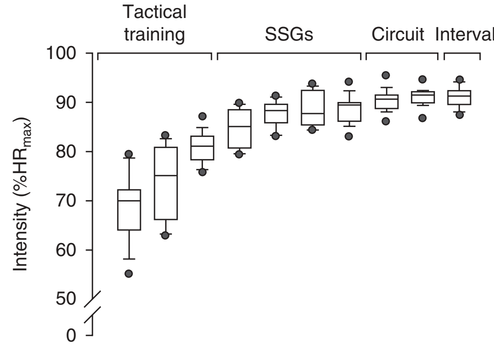

Fig. 3. Mean (±90% CI) exercise intensity (percentage of maximum heart rate [%HR_{max}]) in various football training activities. **SSGs** = small-sided games.

3.2 Training Studies Comparing SSGs Training with Interval Training

There have been few studies that have examined the efficacy of using SSGs as a conditioning stimulus compared with traditional forms of fitness training. In the first controlled training study to compare both SSGs and generic training, Reilly and White[57] recruited 18 professional youth footballers from an English Premier League football club. Using a parallel matched-group design, players were allocated to a SSGs group or an aerobic interval training group (ITG). Players completed the training twice per week, as part of their normal training, over a 6-week period during the competitive season. The SSGs involved five versus five games, played in intervals of 6×4 minutes, interspersed with 3-minute active recovery at 50–60% HR_{max}. The interval running duration was matched with the SSGs, with a target intensity of 85–90% HR_{max} (active recovery of 3 minutes at 50–60% HR_{max}). All physiological performance measures, including counter movement jumps, 10–30 metre sprints, 6×30 second anaerobic shuttle test, the agility T-test and the multi-stage fitness test, demonstrated similar changes during the study.[57] Based on these results, the authors concluded that both SSGs and interval training are equally effective for maintaining in-season aerobic and anaerobic fitness in elite youth footballers.[57] Unfortunately, the HR responses to each type of training were not reported, making it difficult to determine if both groups received a similar internal training load during the study period. A further limitation of this study was that there was little detail of the periodization and prescription of the SSGs training. For example, the game format was restricted to five versus five for all sessions, and no detail relating to pitch area, rules or coach encouragement was provided.

In a comprehensive training study comparing SSGs with generic interval training, Impellizzeri et al.[58] used a parallel matched-group research design, where 29 youth football players from two junior teams of Italian professional football clubs were randomly allocated to either a SSG or ITG. The 12-week training intervention spanned over 4 weeks of the pre-season and 8 weeks of the competitive season in which the players completed two sessions per week designed to improve aerobic fitness. The interval training comprised a fixed prescription of 4×4-minute efforts at a target intensity of 90–95% of HR_{max}, interspersed by 3 minutes of active recovery at 60–70% of HR_{max}. The SSGs training involved a mix of SSGs, including three versus three, four versus four and five versus five players. Both the duration and training intensity were matched between the groups. The results demonstrated no difference in mean exercise intensity (%HR_{max}) or weekly training load (session RPE) between the groups, with the exception of time spent at >95% HR_{max}, where the SSGs group spent ~30 seconds per session longer in this zone.[58] Fitness test results revealed similar improvements for the ITG and SSG groups for peak oxygen consumption ($\dot{V}O_{2peak}$) [8% and 7%, respectively], lactate threshold (13% and 11%, respectively) and running economy (3% for both groups) over the 12 weeks of training. Notably, the improvements in $\dot{V}O_{2peak}$ for ITG and SSGs for the in-season phase of the study were also very similar to the earlier study of Reilly and White[57] (0.8% and 0.7%, and 0.3% and 0.2%, respectively).

Impellizzeri et al.[58] also examined the influence of generic and specific training strategies on physical performance during matches. The results revealed non-significant increases (pre-season training phase only) in low-intensity activity (forwards, backwards and sideways jogging), high-intensity activity (higher speed running and sprinting) and total distance travelled for both the ITG and SSG groups following the 12-week training period. However, when match performance measures for the in-season phase of training were analysed, the magnitude of the increases (for both groups) in low- and high-intensity activity are considerably smaller.[58]

Previous training studies comparing SSGs training with interval running have demonstrated good research design and high internal validity. However, in the field, there are certain aspects of these studies that rarely occur. For example, it is practically difficult to apply a rigid prescription of interval training that does not have progressive overload when training elite football players. Moreover, in practice, the systematic manipulation of SSGs for the purpose of physical development is problematic, as the technical/tactical training goals of the coach do not always relate to physiological development needs or priorities. Therefore, to examine these issues, Hill-Haas et al.[59] assessed the efficacy of a coach-led SSGs programme and a progressive mixed-methods generic fitness training programme in 25 elite youth football players. Using a parallel matched-group research study design, the players were randomly allocated to either SSG or mixed-generic training groups over a 7-week pre-season training period. In contrast to previous research,[58] this study implemented a mixed-generic training programme (consisting mainly of aerobic power training and prolonged intermittent high-intensity interval training), and a SSGs training programme, incorporating a broad range of game formats (i.e. two vs two to seven vs seven).[59] Although the manipulation of the SSGs training variables (such as pitch area and rules) was less systematic than previous studies, a key difference was the planning and implementation of the SSGs training programme by an experienced coach, which increased the external validity of the study. The main finding of this study was that both coach-selected SSGs training and mixed-generic training (comprising short duration, high-intensity intervals of <90 seconds) were effective at significantly improving yo-yo intermittent recovery test (level 1) performance, but not $\dot{V}O_{2max}$.[59] Notably, there were no between-group or training-induced changes in any other performance measures.

In general, the results of these training studies show that SSGs provide similar changes in aerobic fitness and match performance measures, with the majority of changes in fitness/performance observed during pre-season training. The studies also suggest that more effective use of this training mode is still possible. This may be achieved through systematic manipulation of the training variables. However, it is clear that careful selection of SSG formats and training regimens is required to optimize fitness and performance gains. Combined, the evidence suggests that both SSG and interval training drills are suitable for improving fitness and performance in football players. It is most likely that a mixed-methods approach is appropriate for football training; however, the selection of these should be based on the technical, tactical and performance needs of the players.

4. Limitations of SSGs

The first limitation relates to the current research knowledge into the prescriptive variables that affect SSGs intensity. The current volume of systematic research in this area is small and, consequently, definitive conclusions are difficult to form. Despite offering several advantages, there are also a number of suggested limitations that relate to the implementation of SSGs, including (i) the ceiling effect in achieving high-exercise intensities for highly fit or skilled players; (ii) the ability to replicate the demands of the most intense periods of match play; (iii) the requirement of a high level of technical and tactical proficiency to achieve appropriate exercise intensity; (iv) the risk of contact injuries during training; and (v) and the availability of enough coaches to control and monitor this type of training.

It has been reported that players with the highest $\dot{V}O_{2peak}$ elicited the lowest percentage of $\dot{V}O_{2peak}$ during SSGs,[60] suggesting that either the technical/tactical constraints of the game or the intermittent nature of the exercise can prevent some players from reaching appropriate training intensities.[61] Therefore, it was suggested that players with a high fitness level and a good skill level will not exercise at sufficient intensity to elicit aerobic fitness adaptations under these training conditions. However, in contrast, we have observed a weak but significant positive correlation between fitness level and exercise intensity during various SSGs (figure 4). These results suggest that players with a high fitness level

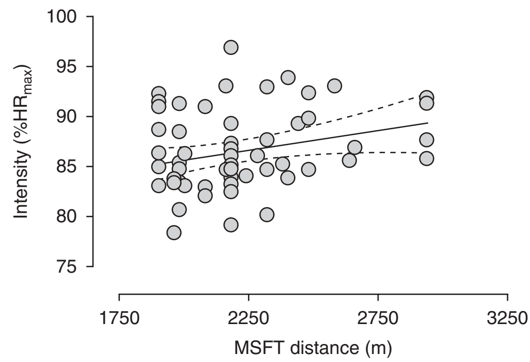

Fig. 4. Relationship between player fitness (multi-stage fitness test [MSFT] distance [m]) and exercise intensity (percentage of maximum heart rate [%HR_{max}]) during various small-sided games, [$r = 0.26$, $p = 0.04$].[45] Full line represents the line of best fit and the dashed line represents 95% confidence intervals.

exercise at a higher intensity during SSGs. Therefore, future research is required to elucidate the possible relationships between fitness, skill and exercise intensity during SSGs.

Additionally, the intermittent nature of SSGs has been suggested to limit the ability of players to achieve sufficient cardiac load for aerobic fitness adaptations. Indeed, Hoff and Helgerud[61] argue that optimal aerobic adaptations are only possible if cardiac output remains elevated for sustained periods during football training, and that exercise intensities of >90% HR_{max} are required for improvements in aerobic fitness. Since SSGs are more intermittent than interval running, it has been suggested that the continual re-setting of the muscular venous pump will compromise cardiac output and consequently prevent a sustained high stroke volume being achieved.[61] It has also been reported that SSGs training may not always simulate the high-intensity, repeated-sprint demands of high level competition,[2] and it is not known if they can be used to replicate the most intense periods of the game. However, these potential physiological limitations to SSGs training may be countered by appropriate manipulation of SSGs training variables.

Moreover, since SSGs involve a combination of technical/tactical ability, decision making and physical exertion, it seems that concurrent abilities may be required to achieve appropriate exercise intensities. Consequently, it is possible that less-skilled players may not be able to consistently sustain the technical skill or tactical proficiency to achieve and maintain the required metabolic strain; as such, training may be counterproductive in terms of playing performance.[14] However, this has not been empirically tested and future studies should examine if low technical skill ability limits the exercise intensity of individual players during SSGs.

Due to the competitive nature of SSGs in football, there may be an increased risk of contact injuries during training,[7] although rule modifications may help minimize this potential problem. The incidence of injuries in skill-based conditioning games in rugby league have been reported to be lower than that of traditional fitness training.[1] However, to date, there have been no studies that have examined the incidence of injuries during SSGs training in comparison to generic training in football.

Other logistic factors involved in the planning of SSGs (e.g. pitch area available, number of staff, number of players available) can also affect the effectiveness of this training mode. These include the ability to control and monitor the intensity of multiple, concurrent SSGs being played on various pitches at any one time. Therefore, a high level of organization and consistent coach encouragement is also needed to maintain player motivation. The use of technology, including real-time HR monitoring of individual players during SSGs, may also promote more effective implementation of SSGs training.

In summary, there are several potential limitations to SSGs training in football. Coaches should be aware of these factors, which may reduce the effectiveness of this mode of training for developing both physical attributes and football proficiency. Therefore, for optimal use of SSGs training to improve aerobic fitness, it is suggested that a systematic approach to manipulating SSG prescriptive variables is adopted, with an emphasis on careful control and real-time monitoring

5. Future Research

Future research is required to further develop our understanding of the training stimulus provided by football-specific SSGs. One important area that requires further investigation is the influence of modifying SSG design variables on the exercise intensity of SSGs training. This systematic review has demonstrated that, with the possible exception of player number, the majority of prescriptive variables have not been investigated thoroughly. Therefore, future research should examine the influences of manipulating selected variables such as pitch area, technical involvements and rule changes. Further research is still required before a complete understanding of how each of the SSG prescriptive variables may influence exercise intensity is gained.

Another important area for future research is the influence of different periodization strategies of SSGs training for the development of physiological, technical skill and tactical proficiency. A number of interesting research questions could be posed. For example, are larger SSG formats (e.g. six vs six) more effectively used in early preseason training, while smaller game formats (e.g. two vs two) be used just prior to the competitive season? Is the overall effectiveness of SSGs training improved when implemented as part of a traditional linear periodization approach, or is it better to implement these games using a 'block periodization model'[62] approach? To date, the training studies comparing the effectiveness of SSGs and interval running suggest that both are equally effective. Consequently, future studies should examine optimal periodization strategies for using both types of training methods for developing football-specific physical qualities.

Additionally, although many studies have investigated the technical requirements of SSGs,[8,34,36,39,41-43,48,50,55,56,63,64] research conducted to date has not been very systematic. Future studies should include detailed notational analysis to provide an improved understanding of the technical skill requirements of various SSGs. This may assist coaches to better understand the link between the technical load and exercise intensity of SSGs training.

One of the major advantages of SSGs training is thought to be the development of tactical awareness and decision-making capabilities, and the transfer of these to match performance. Future research is also needed to understand the nature of the tactical awareness and decision making development provided by different SSG formats. Once established, further research should establish a link between SSGs and the transfer of these skills to match performance.

6. Conclusions

Despite the extensive use of SSGs in football, our understanding of their effectiveness as a training tool for developing physical, technical and tactical skills in football players is not complete. Nevertheless, recent research has improved our understanding of some of the variables affecting SSGs intensity. Future studies are required to increase the understanding of the interaction between the technical, tactical and physical demands of SSGs, and how these can be manipulated to improve the training process for football players. However, at present, it seems that exercise intensity in SSGs can be manipulated by altering factors such as player number, numerical balance between teams, rules of play, the use of goalkeepers, pitch area and coach encouragement. It also appears that similar fitness and performance gains can be made with SSGs as is achieved with traditional interval training methods.

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Correspondence: Dr *Aaron J. Coutts*, School of Leisure, Sport & Tourism, University of Technology, Sydney, Kuring-gai Campus, P O Box 222, Lindfield, NSW 2070, Australia.
E-mail: Aaron.Coutts@uts.edu.au

