INFLUENCE OF GAME FORMAT AND TEAM STRATEGY ON PHYSICAL AND PERCEPTUAL INTENSITY IN SOCCER SMALL-SIDED GAMES

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ABSTRACT

The aim of the study was to compare internal and external load responses of different SSG, using balanced (5v5 Possession and SSG formats) and unbalanced (6v4) teams. Ten elite youth male soccer players were monitored at the start of the in-season period using global positioning system (GPS), heart rate and subjective ratings of intensity (RPE). Results showed higher physiological stress (>90%HR_{max}) in Possession and SSG formats when compared to the unbalanced teams (ES=1.3-2.3). Total and high-intensity distance in SSG (28±25m) and Possession (67±35m) were greater compared to teams of 6 and 4 in the unbalanced scenario. SSG format and team with 6 players had higher proportion of distance running at sub-maximal velocities (0-5.8m/s²). SSG format and team with 4 players saw greater mean acceleration effort (mean acceleration intensity in SSG 1.91±0.27 vs. Possession 1.80±0.20m.s^2, ES=0.4 and Team 4 1.56±0.24 vs. Team 6 1.44±.0.19 m.s^2, ES=1.3). SSG format and team with 6 players had lower starting velocities prior to acceleration efforts (SSG 0.90±0.08 and Team 6 1.11±0.11m.s^2, ES=1.5 and ES=1.8), while velocity at the end of each acceleration effort was greater in the Possession format and Team 4 compared to SSG and Team 6 (Possession 3.54±0.23m.s^2 and Team 4 3.13±0.22m.s^2) compared to the SSG format (ES=0.1) and the team with 6 players (ES=2.3). These data demonstrate that using unbalanced teams can provide an additional form of training prescription to facilitate player specific training within a squad environment by providing different internal and external training responses within a combined drill.

Keywords: *overload, GPS, training load, acceleration, conditioning*

INTRODUCTION

Small-sided games (SSG) are a common form of training used in soccer to elicit high-intensity training stimuli largely through high heart rate responses to promote cardiovascular adaptations (1,2,3). Their versatility makes them attractive to coaches through a large range of variations with which to manipulate game format and subsequent intensity (3). Some of the most common variables employed have altered the number of players (4), absolute and relative pitch area (1,3), use of goalkeepers (5), bout duration and technical rules (6). SSG are often viewed as 'sport-specific' forms of interval training that can replicate or even exceed specific loading indices associated with competitive match-play (7,8,9). Previous research has examined physiological (heart rate and blood lactate) and subjective (RPE) responses to traditional SSG with goalkeepers, with higher physiological cost and rate of perceived found to be higher with smaller player numbers and larger playing areas (4,5,7) Furthermore, motion-analysis through global positioning systems (GPS) has revealed higher total distance covered (TDC) and at higher speeds with more players and more relative playing area (RPA) (4).

Despite a large body of research on the physiological intensity of SSG, it has been proposed that these drills may not effectively simulate the movement demands of match-play in training, with specific reference to high-velocity efforts (7). To be able to repeatedly execute such actions is a key physical requirement in soccer and to decisive moments in competition (10). However, SSG designs may provide environments conducive to promoting mechanical stimuli through heightened acceleration behaviour, stressing the musculo-skeletal system more relative to match demands as a result of the density of these types of efforts in SSG of smaller playing area and short bout durations (9).

In our previous research, we have found SSG with goalkeepers to provide an environment where

total distance increases with more player numbers and playing space available, explained by a higher average velocity of players trying to find space away from their opponents (11). A higher average velocity also makes it harder to accelerate to and decelerate from higher speed given that movement velocity is already relatively high and the confined space in SSG does not allow pronounced high-speed activity (8). It may therefore be suggested that SSG appear to be greatly contextual in how their design affects individual physical and subjective output (2).

Other research comparing SSG with and without goalkeepers (possession) have found games without goalkeepers to be more physiologically and kinematically demanding in semi-professional players (12). Higher heart rate responses were found with less player numbers, with running demands greater with more players in possession formats on the same relative playing area (12). It could therefore be said that there is potential to mix the training design of small group play, with modifications enabling physical stress to be mediated, ensuring greater control over the training process (2,13). The same author took this further by starting to explore SSG with uneven numbers, whereby numerical advantage or disadvantage produced over and under-load situations using a 'floater', with and without the use of goalkeepers (14). It was thought that such rules may heighten the demands on certain players but this could also emphasise the desired game strategy for different teams, whether to press or create space in attacking and defensive settings (14). Using the same relative playing area, there were no differences in heart rate and blood lactate between over- and underloaded teams, although RPE was higher when overloaded. No differences were found with TDC or high-intensity running (>13km/h^{-1}) between different player numbers (14).

However, implementing rules that increased the chance of a team scoring was found to increase intensity in these SSG's (14). Finally, the use of a floater that links play for either team to create temporary overload situations may help develop fitness through more work at sub-maximal

velocities, but no difference was found for physiological and perceptual responses (14). The results of the above studies highlight the different methods of manipulating training intensity within SSG's but all warrant caution with regards to changing technical rules or design as each may have independent effects on subsequent intensity (2,3,4,5,6).

The existing data available on small-sided games with goalkeepers, as possession with or with uneven teams suggest that physical and subjective responses could be influenced by the contextual issues of each, specifically the game strategy employed for success (2,11). Furthermore, the varied format ensures different aims and objectives of players to be successful. For example, the use of goalkeepers may provide more tactical structure and organisation in order to defend the goal (15). In possession games, when their team is in possession of the ball players may try to find space to receive a pass, whereas the team not in possession are trying to close off passing options with short accelerations or track opponents to mark and intercept the ball (16). Finally, games with uneven team numbers, such as 6v4 scenario, will see the overloaded team trying to 'press' together and close down their opponents quickly, minimising time to make a decision and pass to a team-mate (16).

There is little research, however, surrounding how loading responses vary when comparing different formats of small group play and how they can impact training prescription and conditioning for the team and individuals. It is also unclear how different environmental constraints provided, as well as the aims and underlying movement strategies employed by players may tax physiological systems and/or the musculoskeletal system to a greater degree, specifically with regards to the acceleration characteristics that are key in soccer match-play. This would then provide greater understanding of the programming of specific drills and the movements demands they elicit, as part of an appropriately periodized training program.

It is therefore the aim of this study to assess the loading and intensity of three discrete formats of SSG using the same total number of players. These were a traditional 5v5 SSG with goalkeepers, a 5v5 Possession without goalkeepers, and a 6v4 overload format that is possession-based without goalkeepers. In a novel approach, the contrasting formats will be used to show how physical, perceptual and specific acceleration characteristics may differ according to the external load employed. We hypothesise that higher mechanical load, through acceleration behaviour, will be associated with traditional SSG with goalkeepers, while Possession and Overload drills will require a greater kinematic workload, specifically with overloaded teams who may elicit greater physiological responses.

METHODS

Experimental Approach to the problem

The effect of manipulating both player numbers and relative playing area in commonly used soccer SSG's and their effect on subsequent game strategy for success has not been explicitly detailed. The effect of the game environment may have a large influence on perceptual and physical outputs, particularly acceleration behaviour, which has not been well detailed. A better understanding of these demands will aid periodisation of group and individual conditioning in the applied soccer environment to optimize training status for match-play. In a cross-sectional study design, we therefore implemented three different SSG formats; SSG (regular 5v5 with goalkeepers and standard goals); Possession (5v5 without goalkeepers and 6 mini goals), 6v4 overload (without goalkeepers or goals).

Subjects

Ten elite male soccer players from the same squad participate in the small-sided game study (Mean ± Standard Deviation; 18.0 ± 1.2yrs, 182.1 ± 7.9cm, 74.7 ± 6.3kg, 194.3 ± 6bpm; YoYoIR2 1338 ±

249m). Assuming a type 1 error rate of 5% and using published data for mean and SD values we calculated that ten participants provide 80% statistical power to detect a similar effect.

Table 1: Design of each SSG format

	SSG	Possession	Overload
Players	5v5	5v5	6v4
Duration (mins)	4 x 4	4 x 4	8 x 2
Recovery (mins/secs)	2	2	60s
Pitch size (m)	45 x 34	39 x 39	23 x 23
Total area (m²)	1530	1521	529
Area per player (m²)	153	152	53
Goalkeepers	Yes	No	No
Rules	2nd game 2T, 3rd game 3T	2nd game 2T, 3rd game 3T	2nd game 2T, 3rd game 3T (Team of 6)

All players played at a club participating in the Scottish Youth Premier League and UEFA Youth League. Players also had a minimum of two years' experience of full-time training and were accustomed to high-intensity interval training formats used in this study. These players were selected for data collection as they were consistent members of the training squad, whereas other players were called in to senior team training sporadically. All had similar fitness levels as assessed in physical performance testing. During the week, the squad completed 3-4 field training sessions, 3 gym-based strength sessions, one competitive match and one recovery session. All participants were fully informed about the procedures involved in the study and approval for the research study was given by the University of Glasgow ethics committee.

Procedures

The data in this study was collected six weeks in to the in-season period in the 2013-14 soccer

season. All players were familiar with heart rate and GPS equipment having worn them regularly in training prior to the study. Prior to the training intervention, and as part of regular performance assessments, players completed the YoYo Intermittent Recovery Test Level 2 (17) in order to determine their maximum heart rate (HR_{max}). This test was chosen as it had been used consistently by the players team, and has shown to produce valid, reproducible results (9.6% CV) differentiating between soccer players of different standards, positions and at different time points in the season (18).

Small-Sided Games

The design of the three game formats utilized are shown in Table 1. Each SSG format was performed at least twice and in no particular order, separated by a minimum of seven days. The formats used were typical exercises employed at the club throughout the training cycle and thus representative of the training undertaken by this squad at different points of their weekly microcycles. The SSG were performed at the clubs training ground the same time each morning (10:30am) following a 20-minute standardised warm-up on the same natural grass pitch in weather conditions between 10-15°C. Small-sided games took place after the warm-up, passing and tactical functional exercises. Players were advised to maintain their normal nutritional intake prior to each training session, as recommended by the club dietician, with water available *ad libitum*. The study was designed around the commonly used 5 v 5 format played on three different formats: SSG (with goalkeepers and full-size goals), Possession (without goalkeepers and six mini goals) and Overload possession of uneven teams (6 v 4). SSG and Possession 5v5 formats had the same relative playing area (~150m^2), with the overload format smaller in area (53m^2). These three would then represent inherently different conditions and therefore aims of the players participating in order to be successful in the drill format. Bout duration was different for the 6 vs. 4 game given the imbalance in players on each team and to ensure sustained high-work rate for the duration, though total time was matched for all

formats (sixteen minutes). Each drill would represent common formats in the soccer environment whereby, depending on the coaching staff aims, goalkeepers may not always be required, different player numbers available and some individuals may require specific physical or technical-focused training. Resources available did not allow for the measurement of the time the ball remained in play. The design used in each game format is shown in Table 1. In Possession and Overload formats, the objective was to complete eight consecutive passes in order to score a point. The second and third games were designated two and three-touch maximum respectively. Players were assigned by the head coach to teams according to general positional roles in SSG and Possession formats and rotated in overload to ensure all players experienced the teams of six and four players.

Internal Load Measures

Physiological load was measured using 5Hz heart rate telemetry (Polar Team2, Kempele, Finland) with monitors worn across the chest measuring five times per second. Intensity of exercise was classified according to four heart rate zones: 60-70%, 71-80%, 81-90%, >90% maximum heart rate (HR_{max}). The mean heart rate (beats per minute), percentage of maximum heart rate and time spent in each zone were analysed using Polar2 Team Software. Polar heart rate technology has previously been validated to show strong agreement with criterion ECG measurements during exercise (19).

External Load Measures

External load was recorded using a 5Hz global positioning system with 100Hz tri-axial accelerometer (GPS, MinimaxX, Catapult Innovations, Scoresby, Australia) previously validated for use in monitoring soccer-specific movements (20). GPS units were positioned between the shoulder blades in a specially designed vest and switched on at least fifteen minutes prior to training to allow sufficient connection to a minimum of six satellites as recommended by Malone et al., (21). Average number of available satellites coverage during sessions was 9±1.1 with horizontal dilution of precision

(HDOP) 0.71 on average (21). Data from GPS and accelerometer were analysed using Catapult Sprint software version 5.0.9.2. Discrete velocity thresholds were similar to those used in previous studies of soccer time-motion analysis (22); 0-3.05 $m.s^2$, 3.06-3.9 $m.s^2$, 4.0-4.7 $m.s^2$, 4.8-5.8 $m.s^2$, 5.9-6.5 $m.s^2$ (High-Intensity), >6.5 $m.s^2$ (Sprinting). Total distance covered, frequency of efforts and percentage of time spent exercising at each of these intensities were recorded. GPS also provided frequency, and distance covered for accelerations and decelerations of different intensities; Low 1-2 $m.s^2$, Moderate 2-3 $m.s^2$, and High >3 $m.s^2$ (4,23). Validity and reliability of the 5Hz Minimax device was reported to be 1.3±0.76 to 3.1±1.37 and 2.03±1.31 to 5.31± 1.2% for linear walking and running and also soccer-specific change of direction activity (20). In terms of accelerations, it has been noted that there is a degree of variation in number of efforts registered, particularly at higher magnitudes (~30%, (24)). As a measure of mechanical load experienced by players, accelerometer-derived PlayerLoad™, a vector magnitude has previously been validated (25,26) and describe the acceleration forces experienced by the body in the three planes of motion, *x*, *y* and *z*. PlayerLoad™ Slow represented activity from these three vectors, but only for movement <2 $m.s^2$ (27).

Statistical Analysis

Results are presented as mean ± standard deviation. Differences between dependent variables (distances, speeds, heart rate and subjective measures) were determined using one-way analysis of variance (ANOVA). Any differences between different game formats (SSG, Possession and 6 vs. 4 Overload) were determined using paired *t*-tests. Bonferroni post hoc tests were used to identify significant differences between parameters in each format. Coefficient of variation (CV) weas calculated by dividing the standard deviation and the mean then multiplied by one hundred. Tests of the data's normality were carried out using a Kolmogorov-Smirnov test, with significance was set at $p \leq 0.05$. Analysis was carried out using IBM SPSS Inc. 19 for Windows. (Chicago, IL, USA). Magnitude-based effects were also determined according to Cohen's *d*. Effect sizes were classified as small (0.2),

moderate (0.5) and large (0.8) (28).

RESULTS

Coefficients of variation for metrics of external load between formats were as follows: total distance 6-9%CV, average velocity 6-10%CV, peak velocity 5-8%CV, Player Load per minute 8-17%CV, acceleration distance 12-97%CV and acceleration efforts 10-102%CV.

Table 2: Physical, physiological and perceptual outputs of different small-sided game formats

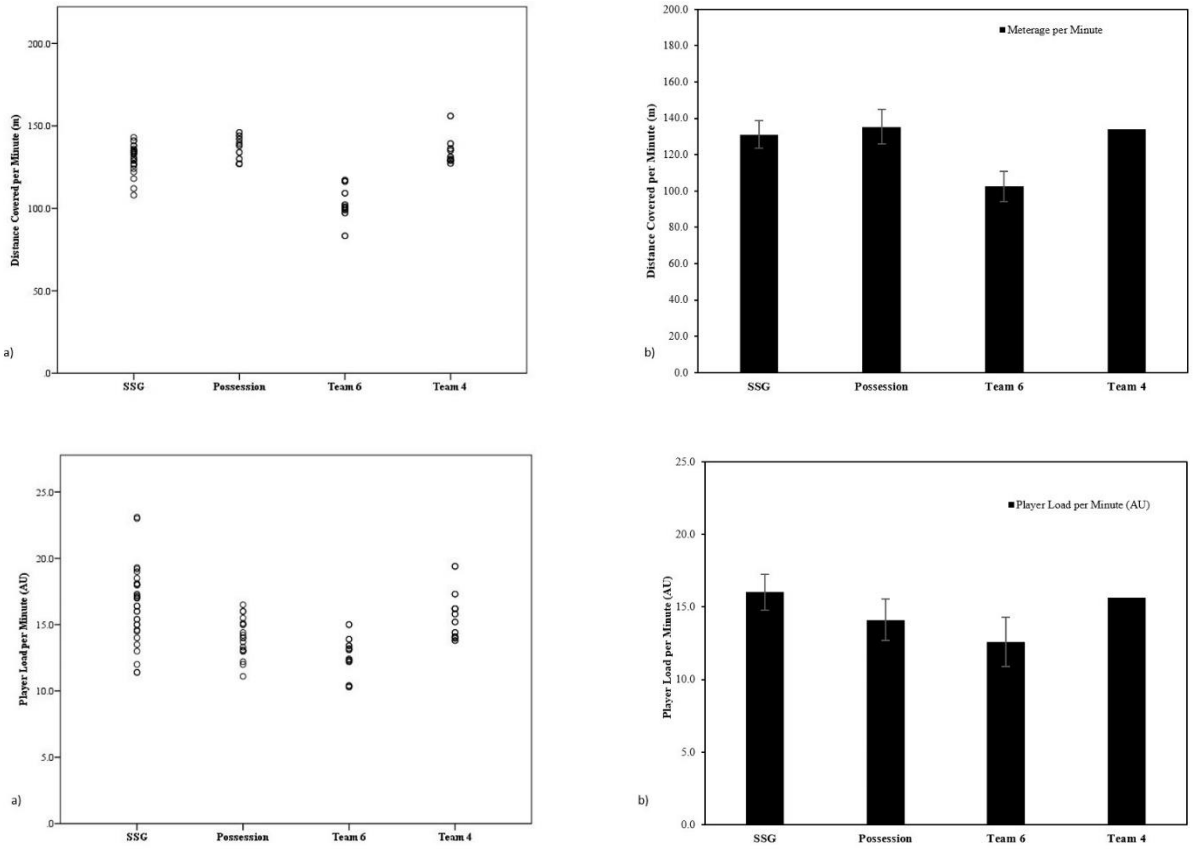
	SSG	Possession	Team 6	Team 4
Total Distance (m)	2097 (127) $^{e**, f**}$	2328 (136) $^{b**, g**, h**}$	824 (74)	1083 (73) ^{d**}
Meterage.min	131 (8) ^{e**}	135 (8) $^{b, g**}$	103 (10)	134 (8) ^{d**}
Distance 0-3.05 m.s^2 (m)	1580 (106) $^{a**, e**, f**}$	1175 (96) $^{g**, h**}$	648 (51)	657 (67)
Distance 3.05-3.9 m.s^2 (m)	300 (77) ^{e**}	481 (74) $^{b*, g**, h**}$	123 (52)	251 (64) ^{d**}
Distance 3.9-4.7 m.s^2 (m)	173 (48) $^{e**, f}$	375 (97) $^{b*, g**, h**}$	44 (25)	126 (43) ^{d**}
Distance 4.7-5.8 m.s^2 (m)	97 (38) $^{e**, f**}$	210 (68) $^{b*, g**, h**}$	9 (6)	24 (19)
High-Intensity (m)	28 (20) $^{e**, f**}$	67 (34) $^{b*, g**, h**}$	0 (0)	0 (0)
High- Intensity Efforts (#)	3 (2) $^{e**, f**}$	6 (3) $^{b*, g**, h**}$	0 (0)	0 (0)
Average Velocity (m.s^2)	1.82 (0.16) ^{e**}	2.11 (0.13) $^{b*, g**}$	1.58 (0.17)	2.18 (0.15) $^{d**, j**}$
Peak Velocity (m.s^2)	6.75 (0.56) $^{a, e**, f**}$	6.38 (0.33) $^{g**, h**}$	4.33 (0.26)	4.84 (0.22) ^{d*}
PlayerLoad.min (AU)	16.2 (2.9) ^{a*}	14 (1.2)	12.6 (1.4)	15.6 (1.7) ^{d**}
PlayerLoad Slow (AU)	110 (17) $^{a**, e**, f**}$	54 (6) ^{g**}	47 (6) ^{c**}	31 (5)
%Heart Rate$_{max}$	88.4 (3.5) $^{e**, f**}$	89.8 (3.1) $^{g**, h**}$	80.4 (4.8)	84.4 (4.9) ^{d}
Time >90%HR$_{max}$ (mins)	5.4 (1.4) $^{e**, f**}$	7.6 (1.7) $^{b, g**, h**}$	1.2 (1.3)	2.6 (2.2) ^{d}
RPE (AU)	6.1 (1.1)	7.9 (0.9) $^{b**, g**}$	5.6 (0.5)	7.7 (0.8) $^{d**, j**}$

m-metres; m.s^2-metres per second; #-number of efforts; AU-Arbitrary Units; RPE-Rating of Perceived Exertion.
^{a} SSG > Possession; ^{b} Possession > SSG; ^{c} 6 Players > 4 Players; ^{d} 4 Players > 6 Players ^{e} SSG > 6 Players; ^{f} SSG > 4 Players; ^{g} Possession > 6 Players; ^{h} Possession > 4 Players; ^{i} 6 Players > SSG; ^{j} 4 Players > SSG; ^{k} 6 Players > Possession; ^{l} 4 Players > Possession (p<0.05, * p <0.01, ** p <0.001)

Internal Load

Table 2 shows the physiological, time-motion and perceptual responses to the different SSG's employed with the same total players. Average heart rate (Figure 3) was higher in Possession and SSG formats (ES=0.4) compared to the Team 4 and Team 6 in the Overload game (ES=1.3 and ES=2.3). Team 4 heart rate was higher than that of the underloaded Team 6 (9%, 4% and 10% and 6%, $p \leq 0.05$, ES=0.4). This was also the case when considering time spent exercising at the highest heart rate zone above 90%HR_{max} for Possession vs. SSG (28%, ES=1.4) and Team 4 vs. Team 6 (53%, $p \leq 0.01$, ES=0.7).

Subjective RPE was also significantly higher in Possession vs. SSG (22%, ES=0.7) and Team 4 vs. Team 6 (27%, $p \leq 0.001$, ES=2.1).



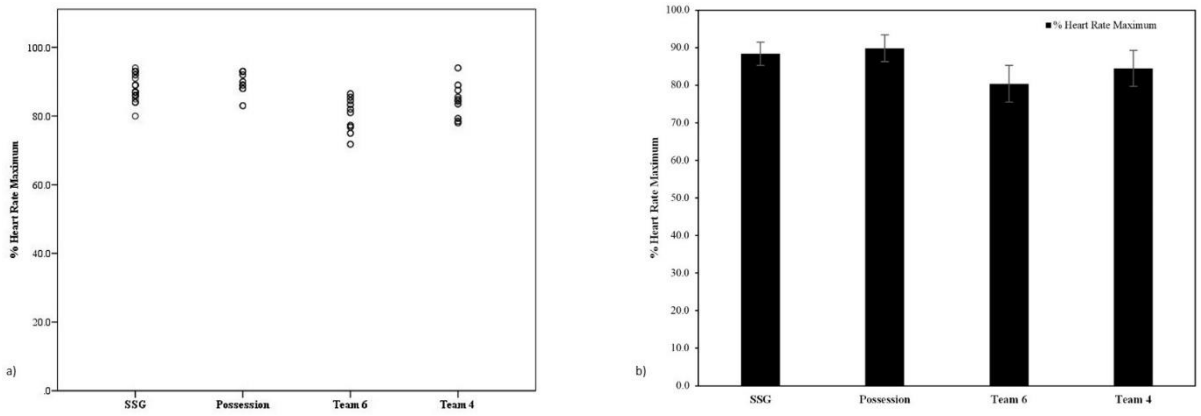


Figure 1a) Individual player relative work rates b) Mean relative work-rate in SSG formats
Figure 2a) Individual player relative mechanical load b) Mean relative mechanical load in SSG formats
Figure 3a) Individual player physiological intensity b) Mean physiological intensity in SSG formats

External Load

Time-motion data was expressed in both absolute and relative terms to account for different bout durations, though total exercise time was the same for each format. Analysis revealed absolute total and relative distance covered to be significantly higher in Possession and SSG compared to the Overload format (9 and 18%, $p \leq 0.001$). The Possession game without goalkeepers had higher absolute total and relative distance (Figure 1, $p \leq 0.001$ and $p \leq 0.05$, ES=3.4). This was the same for Team 4 vs. Team 6 (23%, $p \leq 0.001$). Total distance covered at 0-3.05 $m.s^2$ was greater in the SSG format (72%, $p \leq 0.00$, ES=3.1), though distance covered at all other velocity thresholds was higher in the Possession game compared to SSG ($p \leq 0.05$), Team 4 and Team 6 ($p \leq 0.001$). Low intensity activity (0-3.05 $m.s^2$) was similar for both teams in the Overload format, though Team 4 covered 22% higher distance between 3.05 and 5.8 m/s^2 ($p \leq 0.001$). High-intensity distance and frequency of efforts (above 5.8 $m.s^2$) was greater in Possession than SSG (63% and 50%, $p \leq 0.001$, ES=1.3 and ES=1.1). No high-intensity and sprint activity (>5.8 $m.s^2$) was found in the Overload format. Average velocity was higher in Possession and Team 4 compared to SSG and Team 6 (13-27%, $p \leq 0.001$, ES=1.9 and ES=3.9), peak velocity attained was higher in SSG and Team 4 compared to Possession

and Team 6 (5-35%, $p \leq 0.001$, ES=0.8 and $p \leq 0.01$, ES=2.1). Accelerometer-derived Player Load™ per minute shown in Figure 2 was larger in SSG than Possession (13%, ES=0.9) and Team 4 than Team 6 (19%, $p \leq 0.01$, ES=3.5). Team 4 Player load™ per minute was not different from SSG or Possession ($p \geq 0.05$). Player Load™ Slow was also 50% larger in SSG compared to Possession format ($p \leq 0.001$, ES=2.2), with Team 6 34% higher than Team 4 ($p \leq 0.001$, ES=2.8).

Table 3: Acceleration and deceleration distance covered, number of efforts and efforts relative to time

		SSG	POSS	T6	T4
	(m)	242 (29) [e**, f**]	326 (46) [b**, g**, h**]	112 (18)	158 (30) [d**]
1-2m.s²	**#**	80 (10.0)	90 (17.0) [d]	44.0 (5.3)	49.0 (12.1)
	#.min	4.9 (0.6)	5.6 (1.1)	2.8 (0.3)	3.1 (0.8)
	(m)	69 (21) [e**, f**]	76 (16) [g**, h**]	19 (10)	20 (11)
2-3m.s²	**#**	19 (6.0)	19 (5.0)	5.8 (3.6)	5.3 (3.4)
	#.min	1.2 (0.4)	1.2 (0.3)	0.4 (0.2)	0.3 (0.2)
	(m)	20 (13) [a**, e**, f**]	8 (5) [g**, h**]	1 (1)	2 (3)
>3m.s²	**#**	5 (3.0) [a**]	2 (2.0)	0.7 (0.9)	0.8 (1.6)
	#.min	0.28 (0.20)	0.10 (0.10)	0.04 (0.1)	0.05 (0.10)
	(m)	130 (20) [e**, f**]	173 (22) [b**, g**, h**]	51 (9)	72 (12) [d**]
~1-2m.s²	**#**	78 (13.0)	76 (9.0)	37.1 (8.3)	38.6 (6.8)
	#.min	4.85 (0.84)	4.75 (0.53)	2.32 (0.5)	2.41 (0.4)
	(m)	25 (16) [e**, f]	31 (9) [g**, h**]	6 (3)	15 (8) [d]
~2-3m.s²	**#**	18 (8.0)	16 (6.0)	5.4 (3.0)	11.8 (5.3) [d*]
	#.min	1.10 (0.5)	0.98 (0.35)	0.34 (0.2)	0.74 (0.3)
	(m)	2 (2) [e**, f]	6 (4) [b**, g**, h**]	0 (0)	1 (1)
>-3m.s²	**#**	2 (2.0)	4 (2.0) [b*]	0.6 (0.6)	1.6 (1.5)
	#.min	0.15 (0.15)	0.26 (0.12)	0.04 (0.04)	0.10 (0.09)

m-metres; m/s²-metres per second; #-number of efforts; #.min-number of efforts per minute.
[a] SSG > Possession; [b] Possession > SSG; [c] 6 Players > 4 Players; [d] 4 Players > 6 Players [e] SSG > 6 Players; [f] SSG > 4 Players; [g] Possession > 6 Players; [h] Possession > 4 Players; [I] 6 Players > SSG; [j] 4 Players > SSG; [k] 6 Players > Possession; [l] 4 Players > Possession (p<0.05, * p <0.01, ** p <0.001)

The acceleration profiles of the different formats are displayed in Tables 3 and 4. Accelerations of the lowest magnitude were more frequent and of greater distance covered in Possession compared to SSG ($p \leq 0.05$, 25% and 11%, ES=2.1 and ES=0.7) and both Overload format teams ($p \leq 0.001$). SSG

and Possession were the same for accelerations 2-3m/s^2 with both greater than Team 6 and Team 4 ($p \leq 0.001$). The most intense accelerations distance covered was 60% greater in SSG compared to Possession ($p \leq 0.001$, ES=1.2), both also greater than Team 6 and Team 4 ($p \leq 0.001$). All zones for deceleration distance were greater in Possession and SSG vs. the Overload game teams ($p \leq 0.001$). Team 4 entailed 54% more moderate decelerations -2-3 m/s^2 than Team 6 ($p \leq 0.01$, ES=1.4), and Possession had 50% more decelerations >-3 m/s^2 than SSG ($p \leq 0.001$, ES=0.8).

Table 4: Acceleration characteristics of different small-sided game formats

	SSG	Possession	Team 6	Team 4
Average Acceleration (m.s^2)	1.91 (0.27) $^{e, f**}$	1.80 (0.20) $^{g**, h}$	1.44 (0.19)	1.56 (0.24) ^{d}
Peak Acceleration (m.s^2)	3.85 (0.87) $^{e**, f**}$	3.46 (0.48) $^{g**, h*}$	2.83 (0.53)	2.73 (0.50)
Starting Velocity (m.s^2)	0.90 (0.08)	1.12 (0.18) ^{b**}	1.11 (0.11) ^{l**}	1.31 (0.11) $^{d**, j**}$
End Velocity (m.s^2)	3.43 (1.07) $^{e**, f*}$	3.54 (0.23) $^{g**, h**}$	2.64 (0.19)	3.13 (0.22) ^{d**}
Average Velocity (m.s^2)	1.82 (0.16) ^{e**}	2.11 (0.13) $^{b*, g**}$	1.58 (0.17)	2.18 (0.15) $^{d**, j**}$
Peak Velocity (m.s^2)	6.75 (0.56) ^{a*}	6.38 (0.33)	4.33 (0.26)	4.84 (0.22) ^{d*}
% Start < mean velocity	92.0 (5.5) ^{e**}	99.3 (1.5) $^{b**, g**, h**}$	81.0 (4.3)	91.4 (4.8) ^{d**}
% Start > mean velocity	8.0 (3.2) ^{a*}	0.7 (0.4)	19 (6.7) $^{c**, l**, k**}$	8.6 (3.5)
% Ending >HI Threshold	9.2 (4.9) $^{a**, e**, f**}$	2.5 (3.2) $^{g**, h**}$	0 (0)	0 (0)

m/s^2-metres per second; HI-High-intensity.
^{a} SSG > Possession; ^{b} Possession > SSG; ^{c} 6 Players > 4 Players; ^{d} 4 Players > 6 Players ^{e} SSG > 6 Players; ^{f} SSG > 4 Players; ^{g} Possession > 6 Players; ^{h} Possession > 4 Players; ^{i} 6 Players > SSG; ^{j} 4 Players > SSG; ^{k} 6 Players > Possession; ^{l} 4 Players > Possession (p<0.05, * p <0.01, ** p <0.001).

Table 4 shows the average magnitude acceleration were 18-24% greater for both SSG and Possession compared to both Team 6 and Team 4 ($p \leq 0.001$) and Team 4 8% greater than Team 6 ($p \leq 0.05$, ES=0.5). Starting velocity for each acceleration effort was 15-45% higher in Team 4 compared to Team 6 and SSG (both $p \leq 0.001$, Figure 4), with Possession 24% greater than SSG ($p \leq 0.001$,

ES=2.2). SSG and Possession had higher velocity at the end of acceleration efforts compared to both teams in the Overload format (11-25%, $p \leq 0.001$, ES=0.4-2.5), with Team 4 15% larger than Team 6 end velocity ($p \leq 0.001$, ES=2.3). Significantly more acceleration efforts commenced below the average velocity of the game format in Possession, SSG and Team 4 vs. Team 6, 18% more ($p \leq 0.001$). This was also the case for Possession compared to SSG (8%, $p \leq 0.001$, ES=1.6) and Team 4 with Team 6 (11%, $p \leq 0.001$, ES=2.2). Significantly more acceleration efforts began above the average velocity of the drill in Team 6 versus all other teams ($p \leq 0.001$). The proportion of acceleration efforts ending above the high-intensity velocity threshold of 5.8 m/s^{s} was 72% larger in SSG compared to Possession ($p \leq 0.001$, ES=1.6), with both more numerous than Team 6 and Team 4 ($p \leq 0.001$).

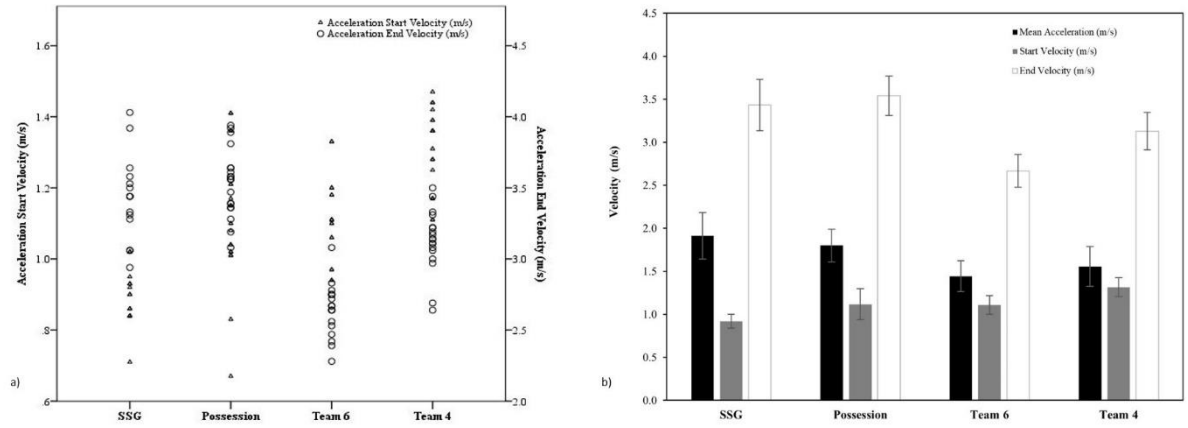


Figure 4a) Individual starting and end velocities for acceleration efforts b) Mean acceleration effort characteristics

DISCUSSION

The aim of this study was to quantify the physical and perceptual intensity of three different formats of SSG, using the same total player numbers. This is one of the first studies to examine the effect of each of these discrete training designs on physical outputs, with specific regard for accelerations. As we hypothesized, the results did show differences in physical and perceptual demands with Possession and SSG formats as well as the overloaded team in the 6v4 scenario, with the outputs of

the overloaded team actually comparable to those of the larger SSG and Possession drills. Mechanical load, via density and nature of acceleration efforts, may be evident in SSG formats employing both even and unbalanced teams. The results therefore show aerobic and mechanical stressors can be mediated by manipulating game format of relative playing area, player numbers and rule changes for specific conditioning purposes.

The aerobic load of small-group play was greater in Possession and SSG formats where heart rate was similar to that previously reported (11) (89.8 ± 3.1 and 88.4 ± 3.5% HR_{max} vs. 94.6 ± 4.1 and 92.1 ± 4.0% HR_{max}), 88.8 ± 2.3% HR_{max} with goalkeepers (12) and 91% HR_{max} in possession games (12). The time spent exercising >90% HR_{max} was also greater in the Possession format, which may provide a beneficial stimulus to promote cardiovascular conditioning in a sport-specific manner (29). The slightly lower heart rate associated with the Overload game is similar to that reported by Hill-Haas et al., (14) in uneven teams of four and six players (84.4 ± 5.9% HR_{max} and 80.4 ± 4.8% HR_{max} vs. 83.1 ±4.0% HR_{max} and 81.4 ± 5.1% HR_{max}). The difference between these teams was found to be more significant in the present study, favored more in the overloaded Team 4 as was also the case for perceived intensity when compared to the previous study. This emphasises the physiological demands required of overloaded teams to work harder when not in possession of the ball and the need to press as a coordinated defensive unit, elevating cardiovascular response in the two-minute bout. The lower average heart rate achieved compared to the other formats may be a result of the lower bout duration employed which is the result of a ‘lag’ in kinetics to attain higher heart rates (30). The numerical advantage of players may then have contributed to the lower heart rate due to the availability of passing options and necessity to cover less space in which to find space and maintain possession.

In terms of external load, absolute distance covered and high-intensity activity were heightened in

Possession and SSG formats, with TDC (expressed as meters per minute) considerably higher in this study than that of Hill-Haas (14) on the same relative playing area with player numbers matched (108 vs. 135 $m.min^{-1}$). However, Team 4 was not different to this as the present study had significantly higher meterage in the overloaded team compared to that of the aforementioned study in sub-elite players (134 vs. 106 $m.min^{-1}$). Studies have also demonstrated decreased TDC in soccer games using goalkeepers compared to possession-based games (12,15). This may be due to increased organisational aspects and positional roles when goalkeepers are included. The design of pitch and duration of bouts of each game in this study may have influenced higher running loads in SSG and Possession compared to the Overload game. Higher relative playing area and bout duration saw increased TDC and high-intensity activity with more space allowing longer accelerations of higher magnitude, also being more conducive to attaining higher peak velocities (4,11), though these were still considerably lower than that in match play (6.75 vs. >8.5 $m.s^2$, (7)). Moreover, high-velocity activity may not be feasible in Overload games due to even less absolute and relative space in which to generate high-speeds, meaning supplementary maximal velocity exposure may be required. These findings may also reflect the underlying context of players to find space away from opponents to recover the ball meaning more continuous running and higher mean velocity. Coutinho et al., (31) suggested youth players, as in the present study, may rely on cues of space regarding pitch length whereas senior player's movement is more synchronized and related to that of other players 'local proximity', utilizing lateral spaces and width more favourably. This may be the case for Possession and SSG in this study, with the Overload game requiring Team 4 to increase meterage to press and dispossess their opponent with numerical superiority. Furthermore, it has been put forward by Seifert and colleagues that player's movements may be a result of continual functional adaptation that derive from the game design in order to maximise success (32). Indeed, the dynamic environment of SSG's channel relationships and subsequent behaviour of each team and individual players (33).

Other studies have examined acceleration behaviour, either as distance covered or frequency of efforts (4,23), though existing literature on detailed acceleration-deceleration characteristics of SSG formats is scarce. The playing environment and game strategy therefore also reflect the nature of the start and end velocities of acceleration efforts, with greater magnitude accelerations and peak velocities attained in efforts starting from lower intensities (such as those in SSG, where average velocity is lower than possession, and higher in Team 4 than Team 6). Despite having different game objectives, the higher average velocity of Possession (2.11 $m.s^2$) and Team 4 (2.18 $m.s^2$) in their respective drills means it is harder to achieve higher changes in speed (acceleration) due to the comparatively high exercise (starting) velocity, hence why SSG entailed higher mean intensity and distance of acceleration efforts and peak velocity attained. This is also reinforced by the proportion of acceleration efforts beginning above or below the average velocity overall for each format, with less acceleration efforts observed above the mean velocity in Possession and Team 4 because of the higher existing work-rates required in these formats. With the lower average starting velocity, the peak acceleration was greatest in SSG and peak deceleration highest in Possession with the higher starting velocity requiring more force to brake and change direction, both higher than that found by previously found in similar formats (4). The greater space available could also accommodate higher-intensity activity >5.8 m/s^2 although accumulated distance here is comparatively low versus match-play (7), as is the peak velocity attained due to spatial constraints. Conversely, higher-intensity deceleration distance and efforts were more numerous in Possession and Team 4 likely as a result of their higher work-rate and average velocity from which to decelerate in order to perform cutting and change of direction actions necessary to press the ball carrier and close-down opponents. Also, peak acceleration in Team 6 may result from the lower starting velocity of acceleration efforts compared to Team 4. Interestingly, the density of relative accelerations and decelerations 2-3 $m.s^2$ were similar to that of those reported in match-play (7), highlighting the mechanical demands associated with

small-sided game formats (9). The strategy likely varies within each format to influence running outputs. SSG with goalkeepers may be more organised and positional with logical build-up of play to the opponent's goal, whereas possession is more continuous and dynamic with multiple goal options meaning less organisation in terms of rigid playing formation. On the other hand, the numerical imbalance imposes greater demands teams with inferior numbers to work together to reduce opponents passing options and time in possession, forcing errors and conceding possession.

The larger contribution of Player Load™ Slow also suggests SSG and Team 6 are lower mechanical intensity in nature compared to Possession and Team 4 which entail higher mean running velocity therefore less activity <2 m/s^2 as shown by Player Load™ Slow metric, performing a greater proportion of distance at lower speed thresholds with Possession and Team 4 covering more distance in the moderate and high intensity velocity zones. A higher value of Player Load™ per minute in SSG and Team 4 could also illustrate the increased neuromuscular demands through player interactions that involve acceleration-deceleration and tolerance of muscular forces indicative of intermittent, change of direction activity profiles in these drills (13).

The results showed novel findings pertaining to acceleration behaviour from different SSG formats employed and could be applicable to other soccer populations. Despite this, there are some limitations. The study comprised of a small number of observations and from one population of elite youth soccer players and at one in-season time point. Future research may be directed to other professional leagues to observe any cultural differences in physical and perceptual outputs from these SSG formats as well as the effect of any strength and conditioning interventions at different stages of the training calendar, confirming the external validity of our findings.

CONCLUSION

The environment provided, namely the balance of teams and relative area at each player's disposal would seem to be large factors in mediating physical and subjective loading responses. The spatial-temporal demands are increased with less space where players have less time for decision making, needing to the dynamic environment. Additionally, the aims and subsequent strategy of certain SSG drills may also dictate the extent of physical and perceptual loads to then target specific groups. As a result, in the overload game, for example, it may be possible to concurrently achieve a dual stimulus of lower-intensity technical and high-intensity physical loads for the under-and overloaded teams respectively. Therefore, we have shown how it may be possible to subject players to different types of loading within the same small-sided game format, to the same extent as traditional SSG and possession formats. Despite a lack of high-velocity volume, smaller absolute and relative space of an overload format may induce a greater biomechanical load through density of accelerations and changes in direction as the space is congested. On the other hand, SSG and possession games of even teams and higher RPA seem to produce greater aerobic loads, higher peak velocities and neuromuscular taxing. Subjecting players to different pitch designs and game conditions may be beneficial for exploring movement choice and cognitive processes pertaining to decision-making and game intelligence This may provide valuable information in periodising the weekly training plan and to develop team or individual conditioning.

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