



External Load Variations Between Medium- and Large-Sided Soccer Games: Ball Possession Games vs Regular Games with Small Goals

by

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This study compared external load variations between 5 vs 5 and 10 vs 10 sided game formats played under two conditions: (i) a ball possession game with two floaters, and (ii) a regular game with goalkeepers and small goals. Twenty-two professional soccer players participated in this study: four central defenders, four wide defenders, nine central midfielders, three wide forwards, and three strikers. Total distance (TD), running distance (RD), sprinting distance (SD), number of sprints (NS), and player's training load (PL) were recorded by GPS units. Within-format analyses revealed very likely large increases in TD (20.0%, [9.2; 31.9]; effect size (ES): 1.48, [0.71; 2.25]) and RD (130.9%, [20.2; 343.7]; ES: 1.32, [0.29; 2.35]) during the regular game when compared to the ball possession game in the 5 vs 5 format. In the 10 vs 10 format, large increases in TD (27.9%, [17.7; 39.1]; ES: 3.54, [2.34; 4.74]) and PL (27.4%, [12.6; 44.1]; ES: 2.46, [1.20; 3.72]) were observed in the regular condition when compared to the ball possession condition. Between-formats analyses revealed that, in the 10 vs 10 format, when compared to the 5 vs 5 format, RD was very likely larger (123.5%, [33.7; 273.7]), as was SD (195.8%, [20.5; 626.2]). However, very likely large decreases in PL were observed in the 10 vs 10 format (-19.6%; [-29.4; -8.3]) in the ball possession condition. Unclear differences were revealed based on variations in external load variables between formats in the regular condition. Smaller formats reduce the area available for running and sprinting and, thus, may be more adequate for increasing player's training load (based on accelerometer data).

Key words: small-sided games, drill-based exercises, soccer, training, external load.

Introduction

Several studies on soccer training have investigated different types of games (i.e., small-, medium-, and large-sided games) to promote improvements in players' and teams' tactical performance (Dellal et al., 2012; Owen et al., 2014). As a part of these studies, the use of GPS devices has improved external load monitoring by including important variables based on distance covered, speed, and acceleration (Casamichana et al., 2013; Cummins et al., 2013). Some studies have

found that the type of game being practiced, the player's position, or the player's skill can influence the number of sprints, total distance covered, and distances covered within different speed zones (Casamichana and Castellano, 2010; Clemente et al., 2014; Gonçalves et al., 2017). Moreover, altering playing conditions (i.e., game rules or objectives) and game formats (i.e., the number of players per team and/or pitch size) may change physical (external load) and physiological (internal load) demands imposed on

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players (Atli et al., 2013; Casamichana et al., 2015; Davids et al., 2013).

A comparison between 4 vs 4 and 6 vs 6 game formats suggests that exercise intensity decreases as the size of the game increases; a similar suggestion has been extracted from a comparison between 7 vs 7 and 10 vs 10 game formats (Owen et al., 2014; Rebelo et al., 2016). These findings suggest that larger formats are more appropriate for developing endurance needed to perform intense aerobic actions for longer periods (Mara et al., 2016). In addition, using larger playing areas and having more players per team may encourage players to increase their sprinting distance in an attempt to create longer pass lines or to exploit the length of the field (Castellano et al., 2013; Jones and Drust, 2007). However, smaller formats seem better for increasing exercise intensity and the number of accelerations and decelerations actions by players (Clemente et al., 2017).

In addition to the game format, playing conditions (i.e., game rules/objectives) can influence training loads (Joo et al., 2016). Some studies suggest that acute physical and physiological responses are usually greater when small goals are used (compared to ball possession games), with limited ball touches and with coach encouragement (Clemente et al., 2014; Halouani et al., 2014). Ball possession games have been compared to regular games (i.e., games which include goals and goalkeepers) for small- (3 vs 3) and medium-sided (6 vs 6) games (Belozo et al., 2016) as well as for medium- (5 vs 5 and 7 vs 7) and large-sided games (10 vs 10) (Gaudino et al., 2014). Gaudino et al. (2014) suggest that ball possession games present lower physical demands regardless of the number of players per team. However, this study altered the number of players and the relative area (i.e., area per player) at the same time, hindering the understanding gained regarding the influence of playing conditions on formats with the same area per player. Therefore, the research is inconclusive regarding the management of training loads by altering playing conditions in different medium and large formats (Abade et al., 2014; Aguiar et al., 2012). A comparison between game formats that employ similar relative areas may help clarify this issue.

Considering the issues mentioned above,

understanding the effects of game formats may help coaches to better plan training loads using medium- and large-sided games (Issurin, 2010). Testing the impact of a medium-sized game (5 vs 5) versus a large-sided game (10 vs 10) will allow coaches to realize the true effects that game size has on physical demands imposed on players during these games. This should also help coaches identify which kinds of task constraints should be used to optimize the training process and to adjust them to the players' needs. Moreover, a better understanding of the effects of regular games versus ball possession games will enhance the knowledge we currently have about the magnitude of the changes that may occur by varying the rules of the game. Therefore, the purpose of the present study was to compare the effects of different game formats (medium and large) on external training loads imposed on professional soccer players.

Methods

Participants

Twenty-two professional soccer players (24.63 ± 2.84 years; 180.94 ± 6.49 cm; 77.19 ± 6.46 kg; 52.99 ± 5.01 ml·kg⁻¹·min⁻¹ VO_{2max}) from a Portuguese soccer team participated in this study. Players were grouped according to their playing position: central defenders (CD: n = 4), wide defenders (WD: n = 4), central midfielders (CM: n = 9), wide forwards (WF: n = 3), and strikers (ST: n = 3). Participants signed an informed consent form prior to the commencement of the study. The experiment was conducted in line with the ethical standards of the Declaration of Helsinki.

Experimental Approach

This observational study comprised regular training sessions of the first four weeks of the season, all of which were conducted at the same time of day (10.00-11.30 a.m.) and similar temperature ($21.2 \pm 2.3^{\circ}\text{C}$). All sessions started with a standardized 15-min warm-up which consisted of jogging, dynamic stretching, along with balance and agility exercises. To standardize players' physical conditions, only games that were performed immediately after this warm-up were included in the analysis. Players had been familiarized with game objectives and rules as part of their training routine prior to the study. Only the most frequent games played during the 4-week period were included in the analysis

(namely, 5 vs 5, and 10 vs 10 formats), all of which were played under two conditions. The first condition was a ball possession game with two floaters (+2 – momentary numerical superiority in the team with ball possession), the aim of which was to keep possession of the ball for as long as possible. The second condition was a regular game that included two goalkeepers (+GK) and which was played with small goals; the objective of this games was to score as many goals as possible. Full descriptions of the game formats and their conditions are given in Table 1. Verbal encouragement was provided by coaching staff during all games. Extra balls were available to quickly restart the game in case the ball went out of play. Resting periods were excluded from the analysis.

Medium- and Large-Sided Games

Table 1 presents the different game formats and playing conditions investigated in the study.

External Training Load

The external load was monitored using a 10-Hz GPS devise (including EGNOS correction) (JOHAN Sports, Noordwijk, Netherlands) with an embedded 100-Hz triaxial inertial sensor (accelerometer, gyroscope, and magnetometer). The literature has reported high validity and reliability of the 10-Hz GPS device to record position and speed in sport settings (Scott et al., 2016). The measurement error of this equipment has been reported as $2.5 \pm 0.41\%$ for total distance covered (Clemente et al., 2017).

The external training load variables analyzed in this study were total distance per minute (TD), running distance per minute (RD – distance covered at speed of 14-20 km/h), sprinting distance per minute (SD – distance covered at speed above 20 km/h), number of sprints (NS – number of times that players reached 20 km/h or faster) and player's training load (PL) per minute. The PL was calculated as the sum of the squared rates of change in acceleration in "n" consecutive moments of the sided games along the three movement axes, where "ay" represents the acceleration along the forward-backward axis, "ax" refers to the acceleration along the sideways axis, and "az" to the vertical axis) (Boyd et al., 2011). The PL is expressed in arbitrary units and indicates changes in players' accelerations over time (Schelling and

Torres-Ronda, 2016), which might be related to athletes' changes of direction, impacts, and collisions throughout the games.

Statistical Analysis

Results are presented as either means and standard deviations (SDe) or percentage differences and 90% confidence intervals (90% CI). Between-formats and between-bouts differences were analyzed using standardized differences of effect size (ES), with a 90% CI (Cohen, 1988). ES was classified as trivial (< 0.2), small (0.2-0.6), moderate (0.6-1.2), or large (> 1.2) (Batterham and Hopkins, 2006). Probabilities were calculated by considering the smallest worthwhile changes (SWC, $0.2 \times$ between-subjects SD) (Hopkins et al., 2009). Qualitative probabilistic mechanistic inferences of the true effects were made using these probabilities (Hopkins et al., 2009). The scale for qualitative probabilities was as follows: 25-75% = possible; 75-95% = likely; 95-99% = very likely; > 99% = almost certain (Hopkins et al., 2009).

Results

Table 2 presents comparison between ball possession games and games played under regular conditions in terms of external load variables per minute during each sided game. Noteworthy differences included large increases in TD (20.0%, [9.2; 31.9]; ES: 1.48, [0.71; 2.25]) and RD (130.9%, [20.2; 343.7]; ES: 1.32, [0.29; 2.35]) in the 5 vs 5 regular condition game when compared to the 5 vs 5 ball possession game. Large increases in TD (27.9%, [17.7; 39.1]; ES: 3.54, [2.34; 4.74]) and PL (27.4%, [12.6; 44.1]; ES: 2.46, [1.20; 3.72]) were found in the regular condition 10 vs 10 game when compared to the 10 vs 10 ball possession game.

Comparisons between formats of play during the ball possession condition are shown in Figure 1. The average TD increased in the 10 vs 10 format with a trivial effect (1.4%, [-10.3; 14.7]) during ball possession conditions. Running distance was meaningfully greater in the 10 vs 10 format than in the 5 vs 5 format (123.5%, [33.7; 273.7]). Sprinting distance was also larger in the 10 vs 10 format (195.8%, [20.5; 626.2]). Furthermore, the number of sprints was moderately greater in the 10 vs 10 format (44.3%, [-60.3; 424.9]). Large decreases of player's training load were observed when comparing the 10 vs 10

format to the 5 vs 5 format (-19.6; [-29.4; -8.3]).

Moderate increases in total distance (6.3%, [-5.5; 19.6]) and trivial decreases in running distance were found in the 10 vs 10 format compared to the 5 vs 5 format (-1.9%, [-48.4; 86.6]).

Sprinting distance was slightly greater in the 10 vs 10 format (55.2%, [-95.4; 514.1]). Additionally, moderate increases in the number of sprints were found in the 10 vs 10 format (55.0%, [-79.3; 159.1]).

Table 1

Sided games' formats and playing conditions.

SSG	Pitch dimensions (m)	Area per player (m ²)	Number of bouts	Bout duration (min)	Rest between bouts (min)
5 vs 5 + 2,	40 x 31	103 (including floaters)	2	6	3
5 vs 5 + GK	40 x 31	124	2	6	3
10 vs 10 + 2	52 x 44	104 (including floaters)	2	10	3
10 vs 10 + GK	52 x 44	114	2	10	3

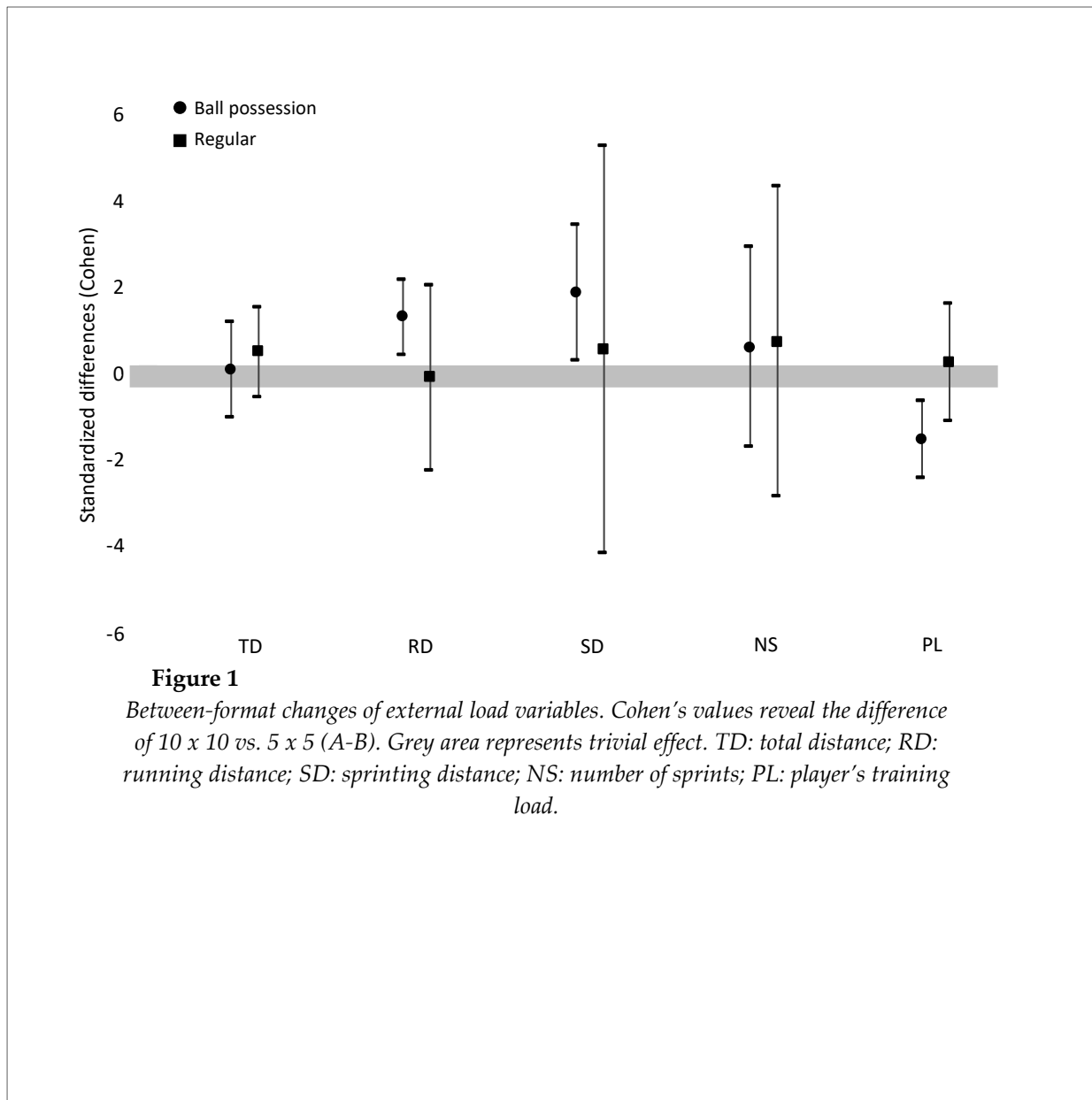
Legend: 5 vs 5 + 2: 5 vs 5 ball possession game with 2 floater players; 5 vs 5 + GK: 5 vs 5 game with goals and goalkeepers; 10 vs 10 + 2: 10 vs 10 ball possession game with 2 floater players; 10 vs 10 + GK: 10 vs 10 game with goals and goalkeepers.

Table 2

Between-condition variations of external load variables per sided-game.

Day	Variable	M (SDe) BP	M (SDe) Regular	% difference (Regular-BP)		Standardized difference (Regular-BP)		% greater/similar/lower values for Regular vs. BP
				Value	[90%CI]	Value (Magnitude)	[90%CI]	
5 x 5	TD (m/min)	79.64 (8.69)	95.63 (11.06)	20.0	[9.2; 31.9]	1.48 <i>large</i>	[0.71; 2.25]	99/1/0 <i>Very likely</i>
	RD (m/min)	2.40 (1.27)	5.76 (3.11)	130.9	[20.2; 343.7]	1.32 <i>large</i>	[0.29; 2.35]	96/3/1 <i>Very likely</i>
	SD (m/min)	0.8 (0.7)	0.27 (0.17)	52.9	[-12.7; 167.8]	1.10 <i>moderate</i>	[-0.35; 2.54]	87/6/6 <i>Unclear</i>
	NS (n/min)	0.03 (0.04)	0.12 (0.09)	4.6	[-8.2; 19.1]	0.20 <i>small</i>	[-0.39; 0.79]	50/40/9 <i>Unclear</i>
	PL (g/min)	6.19 (0.85)	6.30 (1.01)	1.4	[-8.5; 12.3]	0.09 <i>trivial</i>	[-0.55; 0.73]	37/41/21 <i>Unclear</i>
10 x 10	TD (m/min)	87.42 (4.91)	111.87 (7.07)	27.9	[17.7; 39.1]	3.54 <i>large</i>	[2.34; 4.74]	100/0/0 <i>Almost certain</i>
	RD (m/min)	4.89 (2.31)	8.73 (4.96)	69.6	[37.6; 109.1]	0.77 <i>moderate</i>	[0.46; 1.07]	99/1/0 <i>Very likely</i>
	SD (m/min)	0.80 (0.86)	1.13 (1.70)	-62.0	[-99.5; 284.6]	-0.52 <i>moderate</i>	[-2.85; 1.81]	23/12/64 <i>Unclear</i>
	NS (n/min)	0.13 (0.12)	0.23 (0.26)	18.8	[-69.8; 366.3]	0.15 <i>trivial</i>	[-1.08; 1.39]	46/29/24 <i>Unclear</i>
	PL (g/min)	5.50 (0.43)	7.00 (0.55)	27.4	[12.6; 44.1]	2.46 <i>large</i>	[1.20; 3.72]	99/0/1 <i>Very likely</i>

TD: total distance; RD: running distance; SD: sprinting distance; NS: number of sprints; PL: player's training load; BP: ball possession; M: mean; SDe: standard deviation



Discussion

This study compared the external training load experienced by professional players during medium- and large-sided games of different formats (i.e., number of players per team and pitch size – 5 vs 5, and 10 vs 10) and playing conditions (i.e., game rules/objectives – ball possession and a regular game with goals and goalkeepers). This is the first study to simultaneously assess the effect of altering the game objective (ball possession vs. goals) and format size (number of players per team and pitch size) on players' physical responses according to their playing position.

In general, the results show that enlarging the format size led to an increase in the external load and that ball possession drills with floaters resulted in a lower physical demand than games with small goals. It was also observed that game formats that were more similar to a formal game involved physical demands that were more specific to each playing position.

The comparison between medium- and large-sided games revealed that larger formats led players to cover greater total, running, and sprinting distances per minute than smaller formats with the same playing conditions (i.e., GK or ball possession). This is in line with other

studies that have indicated increases in physical and physiological demands in professional and amateur players with increases in pitch size (Casamichana and Castellano, 2010; Gaudino et al., 2014; Rampinini et al., 2007), although there has been some heterogeneity in the relative area (which was controlled in this study).

The increase in the distances covered in both speed zones in larger formats may be related to the larger area available for performing high-speed actions. However, the PL did not show the same tendency that the other variables did, possibly because its concept is more closely related to actions that are different from linear running or sprinting (i.e., changes of direction). Considering that the PL reflects changes in acceleration over time (a physical quantity known as “jerk”) (Schelling et al., 2015) and not acceleration itself, it might also present some limitations as a descriptor of exercise intensity and, thus, does not share the tendency of other variables.

Regarding playing conditions within the same format, the 10 vs 10 regular game, which is more similar to a formal game, led to higher total distance covered per minute, player’s training load per minute, and running and sprinting distances per minute than the 10 vs 10 ball possession game. Similar results were found for the 5 vs 5 format, in which the regular game was associated with higher total distance covered and running distance than the ball possession game. These results agree with previous data that suggest that a decrease in the number of high-intensity actions occurs in ball possession games compared to regular games (Belozo et al., 2016).

Additionally, games with goalkeepers have been shown to result in higher total distance covered, very high and maximal speed distances, absolute velocity, and absolute maximum acceleration and deceleration (Gaudino et al., 2014). These results have been explained mainly by an increase in linear behaviors in games with a defined offensive side (GK conditions) (Gaudino et al., 2014). Considering that ball possession games do not require teams to progress on the field during offense, the objective of these games can be reached with smaller displacement, thus decreasing the external load. Therefore, knowledge of the impact of playing conditions on training loads allows for better adjustments of

game characteristics to induce higher (regular games with goals) or lower (ball possession games) physical demands.

Another explanation for the lower external load during ball possession games is related to the floaters (additional players). Although this condition has been investigated in some studies (Clemente et al., 2014; Praça et al., 2015; Vázquez et al., 2017), its impact on external loads in medium- and large-sided games has not been thoroughly explored. The present study suggests that the presence of floaters leads to a decrease in the external load, similarly to what is reported for smaller formats in previous research (Praça et al., 2015). Floaters may reduce physical demand by favoring ball possession maintenance and not requiring defenders to follow their markers individually and to focus instead on collective defensive behaviors and improving interpersonal coordination (Praça et al., 2016).

This study has some practical implications. The 5 vs 5 format decreases running distance, but increases the acceleration profile measured by the PL. This suggests that medium-sized games can be used to increase the intensity of exercise in terms of acceleration/deceleration demands. However, large-sided games are more appropriate for imposing increases in medium-to-long distances covered. Coaches may use such information to accordingly use different sided-games to fit the main goal of any given training session.

Future studies should investigate the influence of playing conditions and game formats, such as the number of ball touches and the pitch area per player. These data can help coaches and trainers develop more accurate expectations of the demands imposed on athletes in different medium- and large-sided games. This type of analysis should also be conducted for players of different ages and levels of competition to broaden the understanding of small-, medium-, and large-sided games in different contexts.

Conclusions

This study compared 5 vs 5 and 10 vs 10 formats played under two conditions: (i) a ball possession game with two floaters, and (ii) a regular game with goalkeepers and small goals. Greater total distances per minute were found in the 10 vs 10 regular game than in the 5 vs 5 game, with minimum to moderate effects. Greater values

of the player's training load per minute and running and sprinting distances per minute were also found in the 10 vs 10 regular game, with minimum-to-moderate effects. A smaller external load was observed in the 5 vs 5 format than in the 10 vs 10 format. Regular games resulted in greater

total, running, and sprinting distances per minute than ball possession games. Overall, ball possession games were associated with lower values for the player's external load than regular games.

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