Original Paper DOI: https://doi.org/10.5114/biolsport.2020.98449

Session-to-session variations in external load measures during small-sided games in professional soccer players

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ABSTRACT: The aims of this study were 1) to analyse session-to-session variations in different external load measures and 2) to examine differences in within-session intervals across different small-sided game (SSG) formats in professional players. Twenty professional soccer players (mean ± SD; age 28.1 ± 4.6 years, height 176.7 ± 4.9 cm, body mass 72.0 ± 7.8 kg, and body fat 10.3 ± 3.8%) participated in 3v3, 4v4, and 6v6 SSGs under different conditions (i.e., touch limitations and presence of goalkeepers vs. free touch and ball possession drill) over three sessions. Selected external load measures—including total distance (TD), high-intensity running (HIR, distance covered > 14.4 km·h^{-1}), high-speed running (HSR, distance covered > 19.8 km·h^{-1}), and mechanical work (MW, accelerations and deceleration > 2.2 m·s^{2})—were recorded using GPS technology during all SSG sessions. *Small* to *large* standardized typical errors were observed in session-to-session variations of selected measures across SSGs. TD·min^{-1} showed less variability, having a coefficient of variation (CV) of 2.2 to 4.6%, while all other selected external load measures had CV values ranging from 7.2% to 29.4%. *Trivial* differences were observed between intervals in TD·min^{-1} and HIR·min^{-1} for all SSGs, as well as in HSR·min^{-1} and MW·min^{-1} for most SSG formats. No reductions or incremental trends in session-to-session variations were observed when employing touch limitations or adding goalkeepers. The increased noise observed in higher speed zones (e.g., high-speed running) suggests a need for more controlled, running-based conditional drills if the aim is greater consistency in these measures.

CITATION: Younesi S, Rabbani A, Clemente FM et al. Session-to-session variations in external load measures during small-sided games in professional soccer players. Biol Sport. 2021;38(2):185–193.

Received: 2020-07-03; Reviewed: 2020-07-19; Re-submitted: 2020-07-25; Accepted: 2020-07-25; Published: 2020-08-28.

Key words:
Association football
Performance
High-intensity running
High-speed running
Reliability
Noise

INTRODUCTION

The small-sided game (SSG) is an integrated training approach that combines the technical, tactical, and physiological aspects of soccer. It is very popular among scientists and practitioners as a result of its proven benefits [1, 2]. Researchers have investigated the acute responses and chronic physiological adaptations of soccer players following SSG interventions [1–4], as well as the transfer of the physiological effects of SSGs to match performance [5]. Others, however, have criticized SSGs in recent years, claiming that they offer less controlled physical load than some running-based conditional interventions [2, 6]. It has also been noted that SSGs cannot simulate all the physical demands of a soccer match and, for that reason, are limited in their ability to prepare players for real competitions [7]. Among all limitations, the reduced frequencies of high-demanding efforts (e.g., sprinting) during SSGs as well as the dependency of the physical status of players are among the issues when implementing SSGs [8]. Moreover, it is also known that even considering similarities between SSGs and the match, the latter promotes greater high-demanding speeds in terms of external loads [9].

Session-to-session variations in training load variables have an essential role in ensuring that a training intervention is effective and maximizes physiological stimulus at an individual level [10, 11]. Reducing variation, or noise, in exercise intensity increases the consistency of the stimulus and consequently assures improvements in players' physiological adaptation and performance improvement [12]. While studying the noise of internal load variables (e.g., average heart rate, blood lactate concentration) during SSGs is important primarily for metabolic aspects [13, 14], session-to-session variations in external load measures (e.g., total distance, sprinting distance) are also relevant—especially from a neuromuscular point of view [15, 16]. For instance, it has been reported that higher speed zones of distance covered (e.g., high-speed running) put more strain on hamstring muscles, while high-intensity actions (e.g., accelerations and decelerations) require more use of the quadriceps, adductors, and gluteal muscles [17]. These relationships are of paramount importance to strength and conditioning coaches, who aim to prevent injuries and improve athletes' physical performance by targeting specific muscle groups [18].

Research has shown that manipulating factors such as touch limitations [19], pitch size [13], goalkeeper presence [20], and even tactical rules [14] can influence acute physiological responses to SSGs. For instance, Ngo et al. [14] observed an increase in heart rate response (~4.5%) when using man-marking. Interestingly, the same study found that increased intensity leads to decreased variation (i.e., noise) in physiological response (i.e., internal load) [14]. Although several studies have examined the session-to-session variability of external load measures during SSGs [6, 10, 11, 21–23], researchers have not yet determined the effects that some factors (e.g., touch limitations, goalkeeper presence) have on noise in different SSG formats. Examining a 5 vs. 5 format played at different pitch sizes (38x26 vs. 53x37 m), the coefficient of variation showed very high values for sprinting (133% and 75%, in smaller and larger pitch, respectively), moderate values in jogging and cruising (27–43 and 22–28%, in smaller and larger pitch, respectively) and small values in walking (< 9%) [8]. When evaluating two formats of play (3 vs. 3 and 4 vs. 3) [24], weak reliability (intra-class correlation test) of peak speed (0.08 and 0.09 in 3 vs. 3 and 4 vs. 3 formats, respectively), and weak to moderate reliability of distances covered between 7.3 and 14.3 $km{\cdot}h^{-1}$ and 14.4 and 21.5 $km{\cdot}h^{-1}$ (0.56 and 0.54; 0.74 and 0.28, respectively in 3 vs. 3 and 4 vs. 3 formats) were found. These are examples of differences in the external load measures in terms of variability and reliability when comparing different formats and pitch sizes. Furthermore, other concurrent factors should also be considered, namely the use of specific conditions that aims to strengthen the tactical dimension of the games.

Furthermore, only a few studies have investigated within-interval external load changes during SSGs with soccer players [15, 25, 26]. More research is needed to clarify whether the manipulation of influential factors causes any changes between intervals in different SSG formats. Addressing these issues will help coaches to understand the effects of different task conditions on external load variability and choose drills accordingly. For these reasons, the aims of this study were 1) to analyse session-to-session variations in external load measures, and 2) to examine the differences in within-session intervals across SSG formats among professional players. We hypothesized that high-demanding external load measures will be more variable than low-demanding measures and that some constraints may have a greater effect on controlling the variability.

MATERIALS AND METHODS

Experimental Approach to the Problem

A cohort design was used to analyse the session-to-session variation of external load measures in different formats of SSGs (3v3, 4v4, and 6v6) under different conditions (with and without touch limitations and goalkeepers). The data collection phase lasted from 10 July to 9 April. The same format was tested consecutively to reduce the influence of readiness and physical status on the performance. A three-trial repeated measure design was implemented to examine noise. Training time and environmental conditions were similar for repeated measures of each SSG format with a special condition (e.g., 3v3+Gk and touch limitation) employed maximally during the three consecutive week phase. The same configuration (i.e., same teams, same players, same days) was maintained across all sessions. However, training time (between 17:00 and 20:00) and environmental conditions (ambient temperature and relative humidity ranging from 25 to 38°C and 50 to 80%, respectively) varied greatly over the data collection phase. Data related to external load measures were obtained using global positioning systems during all SSG sessions. All players involved in the study were professional and were familiar with SSGs prior to the experimental period.

Subjects

Twenty professional soccer players (mean ± SD; age 28.1 ± 4.6 years old, height 176.7 ± 4.9 cm, body mass 72.0 ± 7.8 kg, and body fat percentage 10.3 ± 3.8%) participated in this study. All were members of a team competing in the 2018–2019 season of the Qatar Star League (Qatar First Division). Inclusion criteria were (i) at least three years' experience training in professional clubs prior to the start of the study, (ii) a minimum age of 18 years, and (iii) no serious injuries during the data collection phase (following a complete cardiovascular health examination). All players were aware of the experimental procedures and gave informed consent. The study protocol was approved by the university's scientific committee.

Procedures

Small-sided games

SSGs—including 3v3, 4v4, and 6v6 formats—were used in this study. Each format was repeated over three trials with a different special condition. The conditions were touch limitations (with a maximum of three consecutive touches permitted to each player) or free-touch task constraints, as well as adding goalkeepers or performing ball position drills. Three-, four-, and six-minute working intervals were implemented for 3v3, 4v4, and 6v6 SSG formats, respectively. Two minutes were allotted for recovery between intervals. Pitch dimensions were 20 × 27 m, 22 × 32 m, and 28 × 40 m for 3v3, 4v4, and 6v6 SSGs, respectively, and the playing areas were standardized (~90 m^2 per player, excluding the goalkeeper). Goal size (i.e., real match size) were kept consistent in all game interventions. All SSG formats excluded the offside rule and the same coaching staff gave coach encouragement as consistently as possible in all sessions. All throw-ins for restarting the game were performed using goal keepers from their standard positions.

The first two intervals in each format were selected for analysis. The coaching staff, which included one of the authors (a strength and conditioning coach), were directed to ensure consistency in their supervision during all SSG sessions. Balls were kept near the SSG pitch so that coaches could restart the game immediately if a ball left the playing area. For each format, the teams were balanced based on their members' physical and technical abilities (as determined by the coach) to reduce any possible strength or weakness bias.

External load measures

External load measures were recorded during all sessions using portable 10-Hz VX Sport GPS units (VX Sport, Wellington, New Zealand), which are valid and reliable according to Buchheit et al. [27]. External load measures included total distance (TD), high-intensity running (HIR, distance > 14.4 $km \cdot h^{-1}$), high-speed running (HSR, distance > 19.8 $km \cdot h^{-1}$), and mechanical work (MW) that summed the numbers of acceleration and deceleration efforts above and below 2.2 $m \cdot s^2$ thresholds. The thresholds used for acceleration/deceleration efforts (2.2 $m \cdot s^2$) were selected based on practical experiences using the VX GPS system by the coaching staff. All external load measures were standardized by being divided by minutes played (e.g., $TD \cdot min^{-1}$) prior to the analysis so that they could be compared across different SSG formats.

Statistical analyses

The results in the text, tables, and figures herein are presented as means using a 90% confidence limit (CL) or standard deviation (SD) as specified. $TD \cdot min^{-1}$, $HIR \cdot min^{-1}$, $HSR \cdot min^{-1}$, and $MW \cdot min^{-1}$ were

TABLE 1. Day-to-day variations in different external load measures for different small-sided game formats without goalkeeper.

Format	Task constraints	External load	Trial 1 Mean (SD)	Trial 2 Mean (SD)	Trial 3 Mean (SD)	All trials Mean (SD)	ICC (90% CL)	CV (noise) (90% CL)
3V3	Free touch	$TD \cdot min^{-1}$	127.1 (11.4)	130.5 (12.5)	134.1 (14.5)	130.6 (12.9)	0.80 (62; .90)	4.3 (3.4; 6.0)
		$HIR \cdot min^{-1}$	14.0 (4.2)	14.4 (4.6)	14.9 (3.6)	14.4 (4.2)	0.92 (0.83; 0.96)	9.3 (7.3; 12.9)
		$HSR \cdot min^{-1}$	1.6 (0.4)	1.7 (0.4)	1.9 (0.5)	1.7 (0.5)	0.49 (0.15; 0.73)	21.4 (16.6; 30.4)
		$MW \cdot min^{-1}$	4.0 (0.4)	4.0 (0.5)	4.1 (0.6)	4.1 (0.5)	0.48 (0.15; 0.71)	9.4 (7.4; 13.1)
	Touch limitation	$TD \cdot min^{-1}$	129.4 (7.5)	127.4 (11.3)	129.8 (8.6)	128.9 (9.3)	0.74 (0.51; 0.87)	4.1 (3.3; 5.7)
		$HIR \cdot min^{-1}$	14.5 (3.7)	15.0 (4.0)	14.8 (3.8)	14.8 (3.8)	0.89 (0.77; 0.95)	10.3 (8.1; 14.4)
		$HSR \cdot min^{-1}$	2.0 (0.3)	2.0 (0.5)	1.7 (0.4)	1.9 (0.4)	0.51 (0.18; 0.73)	17.7 (13.8; 25.0)
		$MW \cdot min^{-1}$	4.4 (0.6)	4.5 (0.5)	4.1 (0.5)	4.3 (0.6)	0.47 (0.14; 0.70)	9.8 (7.7; 13.8)
4V4	Free touch	$TD \cdot min^{-1}$	125.3 (10.1)	124.4 (10.0)	129.8 (10.0)	126.5 (10.0)	0.67 (0.42; 0.83)	4.6 (3.6; 6.4)
		$HIR \cdot min^{-1}$	15.0 (2.8)	15.1 (3.0)	14.5 (3.8)	14.9 (3.2)	0.78 (0.59; 0.89)	11.6 (9.1; 16.3)
		$HSR \cdot min^{-1}$	1.9 (0.4)	1.9 (0.4)	2.1 (0.4)	1.9 (0.4)	0.60 (0.30; 0.79)	14.2 (11.1; 19.9)
		$MW \cdot min^{-1}$	4.4 (0.6)	4.4 (0.7)	5.2 (0.9)	4.6 (0.7)	0.61 (0.34; 0.79)	10.2 (8.0; 14.3)
	Touch limitation	$TD \cdot min^{-1}$	115.1 (9.5)	117.1 (10.7)	118.1 (10.4)	116.8 (10.2)	0.83 (0.66; 0.91)	3.7 (2.9; 5.1)
		$HIR \cdot min^{-1}$	17.5 (3.9)	16.8 (3.9)	17.7 (3.8)	17.3 (3.9)	0.90 (0.80; 0.95)	8.8 (6.9; 12.2)
		$HSR \cdot min^{-1}$	2.7 (0.7)	2.3 (0.5)	2.6 (0.6)	2.5 (0.6)	0.79 (0.60; 0.90)	12.2 (9.5; 17.1)
		$MW \cdot min^{-1}$	6.8 (1.7)	6.9 (1.3)	6.9 (1.3)	6.9 (1.4)	0.74 (0.52; 0.87)	12.4 (9.7; 17.3)
6V6	Free touch	$TD \cdot min^{-1}$	117.5 (9.3)	118.3 (8.7)	117.0 (9.6)	117.6 (9.2)	0.92(0.83; 0.96)	2.3 (1.8; 3.2)
		$HIR \cdot min^{-1}$	10.3 (3.4)	10.5 (3.6)	10.8 (3.8)	10.5 (3.6)	0.92 (0.84; 0.96)	10.5 (8.3; 14.7)
		$HSR \cdot min^{-1}$	1.9 (0.5)	1.7 (0.5)	1.8 (0.6)	1.8 (0.6)	0.48 (0.23; 0.69)	29.4 (22.5; 43.0)
		$MW \cdot min^{-1}$	6.1 (2.0)	6.6 (2.5)	6.2 (2.0)	6.3 (2.2)	0.79 (0.61; 0.89)	17.0 (13.3; 24.2)
	Touch limitation	$TD \cdot min^{-1}$	108.0 (8.9)	107.7 (8.7)	108.3 (8.9)	108.0 (8.9)	0.87 (0.75; 0.94)	2.7 (2.1; 3.7)
		$HIR \cdot min^{-1}$	9.9 (2.6)	10.3 (2.6)	9.6 (2.6)	9.9 (2.6)	0.84 (0.69; 0.92)	11.1 (8.7; 15.5)
		$HSR \cdot min^{-1}$	1.7 (0.7)	1.8 (0.7)	1.8 (0.6)	1.8 (0.6)	0.91 (0.83; 0.96)	13.7 (10.7; 19.2)
		$MW \cdot min^{-1}$	6.6 (1.9)	6.6 (1.6)	6.3 (1.7)	6.5 (1.7)	0.83 (0.66; 0.92)	11.8 (9.3; 16.6)

Note. TD: total distance; HIR: high-intensity running (> 14.4 $km \cdot h^{-1}$); HSR: high-speed running (> 19.8 $km \cdot h^{-1}$); MW: number of accelerations plus decelerations (> 2.2 $m \cdot s^2$); ICC: intraclass correlation coefficient; CL; confidence limits; CV: coefficient of variation.

computed by dividing the initial measure by the playing time (in minutes) in order to standardize comparisons. To analyse the reliability and session-to-session variation of the external load measures across the three trials, the average measures-consistency intraclass correlation coefficient (ICC) and typical error (TE) of measurements—expressed either as a coefficient of variation or using Cohen's approach (i.e., standardized effect) [28]—were analysed using a spreadsheet designed for this purpose [29]. ICC results were interpreted based on the following classification scale: trivial, small (0.10–0.29), *moderate* (0.30–0.49), *high* (0.50–0.69), *very high* (0.70–0.89), and *nearly perfect* (0.9–1.0) [30]. To examine standardized differences between SSG intervals, the smallest worthwhile change was considered by multiplying between-subject standard deviation by 0.2 [31]. Threshold values for standardized differences were categorized as *small* (> 0.2– < 0.6), *moderate* (> 0.6– < 1.2), *large* (> 1.2– < 2.0), and *very large* (> 2.0) [32].

RESULTS

The results of this study (Tables 1 and 2) showed that TD·min^{-1} had ICCs ranging from *high* to *nearly perfect* (0.67; 0.95) and CVs between 2.2 and 4.6% across all SSG formats. HIR·min^{-1} also showed ICCs ranging from *high* to *nearly perfect* (0.58; 0.96) and CVs between 7.2 and 16.4%. HSR·min^{-1} had ICCs that ranged from *moderate* to *nearly perfect* (0.48; 0.94) and CVs between 12.2 and 29.4%. MW·min^{-1} had *moderate* to *very large* (0.47; 0.87) ICCs and CVs between 9.4 and 22.5%.

Analyses of TD·min^{-1} standardized TE showed 11 small ES values and only one moderate ES value across all SSG formats (Figure 1/A). Eleven small standardized TE values and one moderate standardized TE value were also observed for HIR·min^{-1} (Figure 1/B). For HSR·min^{-1}, there were eight small and four moderate standardized TE values (Figure 1/C). When analysing MW·min^{-1}, standardized TE included seven small values, four moderate values, and one large value (Figure 1/D).

TABLE 2. Day-to-day variations in different external load measures for different small-sided game formats with goalkeeper.

Format	Task constraints	External load	Trial 1 Mean (SD)	Trial 2 Mean (SD)	Trial 3 Mean (SD)	All trials Mean (SD)	ICC (90% CL)	CV (noise) (90% CL)
3V3 +Gk	Free touch	TD·min^{-1}	125.5 (14.9)	127.0 (14.3)	126.8 (11.7)	126.4 (13.7)	0.92 (0.84; 0.96)	3.1 (2.5; 4.3)
		HIR·min^{-1}	20.3 (6.3)	19.6 (5.8)	18.5 (6.6)	19.5 (6.3)	0.88 (0.77; 0.94)	13.9 (10.9; 19.6)
		HSR·min^{-1}	2.1 (0.5)	2.4 (0.7)	2.6 (0.7)	2.3 (0.7)	0.79 (0.59; 0.90)	18.2 (14.2; 25.8)
		MW·min^{-1}	5.3 (1.4)	5.2 (1.3)	5.4 (1.5)	5.3 (1.4)	0.84 (0.69; 0.92)	10.6 (8.3; 14.8)
	Touch limitation	TD·min^{-1}	115.3 (14.8)	115.7 (14.4)	121.2 (15.4)	117.4 (14.9)	0.95 (0.89; 0.97)	2.9 (2.3; 4.0)
		HIR·min^{-1}	16.3 (8.0)	16.2 (7.6)	16.9 (8.4)	16.5 (8.0)	0.96 (0.92; 0.98)	8.8 (6.9; 12.3)
		HSR·min^{-1}	1.6 (0.6)	2.0 (0.6)	2.7 (0.9)	2.1 (0.7)	0.81 (0.62; 0.91)	16.0 (12.5; 22.6)
		MW·min^{-1}	4.6 (1.5)	4.9 (1.4)	5.9 (2.4)	5.1 (1.8)	0.71 (0.50; 0.85)	16.2 (12.6; 23.0)
4V4 +Gk	Free touch	TD·min^{-1}	135.1 (7.3)	128.4 (9.5)	132.4 (8.2)	132.0 (8.4)	0.85 (0.70; 0.93)	2.7 (2.2; 3.8)
		HIR·min^{-1}	18.5 (3.7)	15.3 (3.6)	17.6 (3.3)	17.2 (3.5)	0.58 (0.27; 0.78)	16.4 (12.8; 23.2)
		HSR·min^{-1}	3.2 (0.8)	2.5 (0.8)	2.8 (0.9)	2.8 (0.8)	0.76 (0.54; 0.88)	19.0 (14.8; 26.9)
		MW·min^{-1}	6.5 (1.5)	6.2 (2.1)	6.5 (1.3)	6.4 (1.7)	0.56 (0.26; 0.77)	22.5 (17.4; 32.0)
	Touch limitation	TD·min^{-1}	126.1 (10.0)	122.5 (12.7)	122.8 (12.0)	123.8 (11.6)	0.92 (0.83; 0.96)	2.9 (2.3; 4.0)
		HIR·min^{-1}	17.4 (3.5)	17.0 (3.5)	17.8 (3.9)	17.4 (3.7)	0.90 (0.80; 0.95)	7.2 (5.7; 10.1)
		HSR·min^{-1}	2.5 (0.8)	2.6 (0.8)	2.6 (0.9)	2.6 (0.8)	0.75 (0.55; 0.87)	16.7 (13.0; 23.7)
		MW·min^{-1}	7.2 (3.0)	7.3 (3.3)	6.8 (3.0)	7.1 (3.1)	0.87 (0.75; 0.94)	14.7 (11.4; 20.7)
6V6 +Gk	Free touch	TD·min^{-1}	116.4 (8.7)	115.4 (8.7)	115.8 (8.8)	115.8 (8.7)	0.84 (0.68; 0.92)	3.2 (2.5; 4.4)
		HIR·min^{-1}	11.8 (4.4)	12.8 (2.9)	12.1 (4.4)	12.2 (4.0)	0.76 (0.55; 0.88)	15.9 (12.5; 22.5)
		HSR·min^{-1}	2.4 (1.3)	2.4 (1.1)	2.2 (1.3)	2.3 (1.2)	0.77 (0.57; 0.89)	26.3 (20.4; 37.8)
		MW·min^{-1}	5.9 (1.8)	5.0 (1.8)	5.2 (1.1)	5.4 (1.6)	0.72 (0.49; 0.86)	18.4 (14.4; 26.1)
	Touch limitation	TD·min^{-1}	111.0 (8.4)	112.0 (8.8)	111.0 (8.8)	111.3 (8.7)	0.93 (0.85; 0.97)	2.2 (1.8; 3.1)
		HIR·min^{-1}	13.6 (3.8)	13.9 (3.3)	13.7 (3.4)	13.8 (3.5)	0.92 (0.84; 0.96)	7.8 (6.1; 10.8)
		HSR·min^{-1}	3.3 (2.3)	3.4 (2.1)	3.4 (1.9)	3.3 (2.1)	0.94 (0.88; 0.97)	16.1 (12.6; 22.8)
		MW·min^{-1}	6.6 (1.9)	6.4 (1.9)	5.8 (2.0)	6.3 (1.9)	0.81 (0.63; 0.91)	14.3 (11.2; 20.1)

Note. TD: total distance; HIR: high-intensity running (> 14.4 km·h^{-1}); HSR: high-speed running (> 19.8 km·h^{-1}); MW: number of accelerations plus decelerations (> 2.2 m·s^{2}); ICC: intraclass correlation coefficient; CL; confidence limits; CV: coefficient of variation.

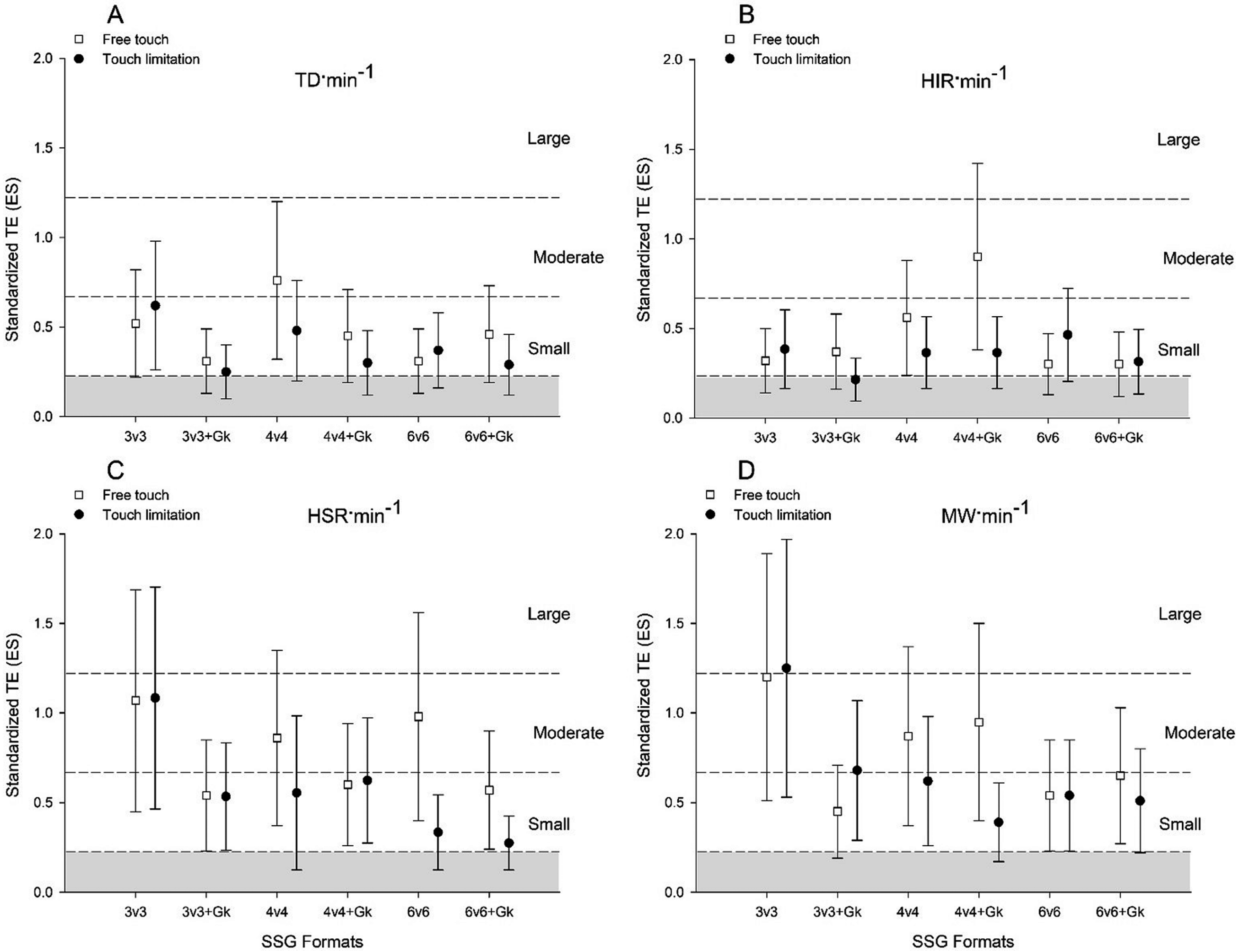

FIG. 1. Standardized typical error [TE] across different small-sided game (SSG) formats with different task constraints for external load measures.

Note. A) TD: total distance; B) HIR: high-intensity running (> 14.4 $km{\cdot}h^{-1}$); C) HSR: high-speed running (> 19.8 $km{\cdot}h^{-1}$); D) W: mechanical work (number of accelerations and decelerations > 2.2 $m{\cdot}s^2$); ES: effect size.

When analysing the differences between intervals across all SSG formats, the results showed *trivial* standardized differences for $TD{\cdot}min^{-1}$ and $HIR{\cdot}min^{-1}$ (Figure 2/A and B). For $HSR{\cdot}min^{-1}$, small standardized differences were observed for 4v4 (ES; 0.27) and 4v4+Gk (-0.21) under free-touch conditions, while the results for all other SSG formats with different conditions were *trivial* (Figure 2/C). For $MW{\cdot}min^{-1}$, there were small standardized decreases in the second interval of 6v6+Gk (ES: -0.22) under free-touch conditions, as well as in 3v3 (ES: -0.53) and 6v6+Gk (ES: -0.26) with touch limitation task constraints (Figure 2/D). The results showed *trivial* differences between intervals for the remaining SSG formats and conditions in the $MW{\cdot}min^{-1}$ measure.

DISCUSSION

This study aimed to examine session-to-session variations among professional soccer players in terms of their external load measures across different SSGs. Also, standardized differences were analysed during within-session intervals. A wide range of standardized TE values were observed in session-to-session variations of selected external load measures across all SSG formats (Figure 1). However, $TD{\cdot}min^{-1}$ showed, in general, less variability than all other external load measures (Tables 1 and 2). Our results also showed *trivial* differences between the intervals for $TD{\cdot}min^{-1}$ and $HIR{\cdot}min^{-1}$ (Figure 2/A and B) and small differences between $HSR{\cdot}min^{-1}$ and $MW{\cdot}min^{-1}$ for some SSGs (Figure 2/C and D).

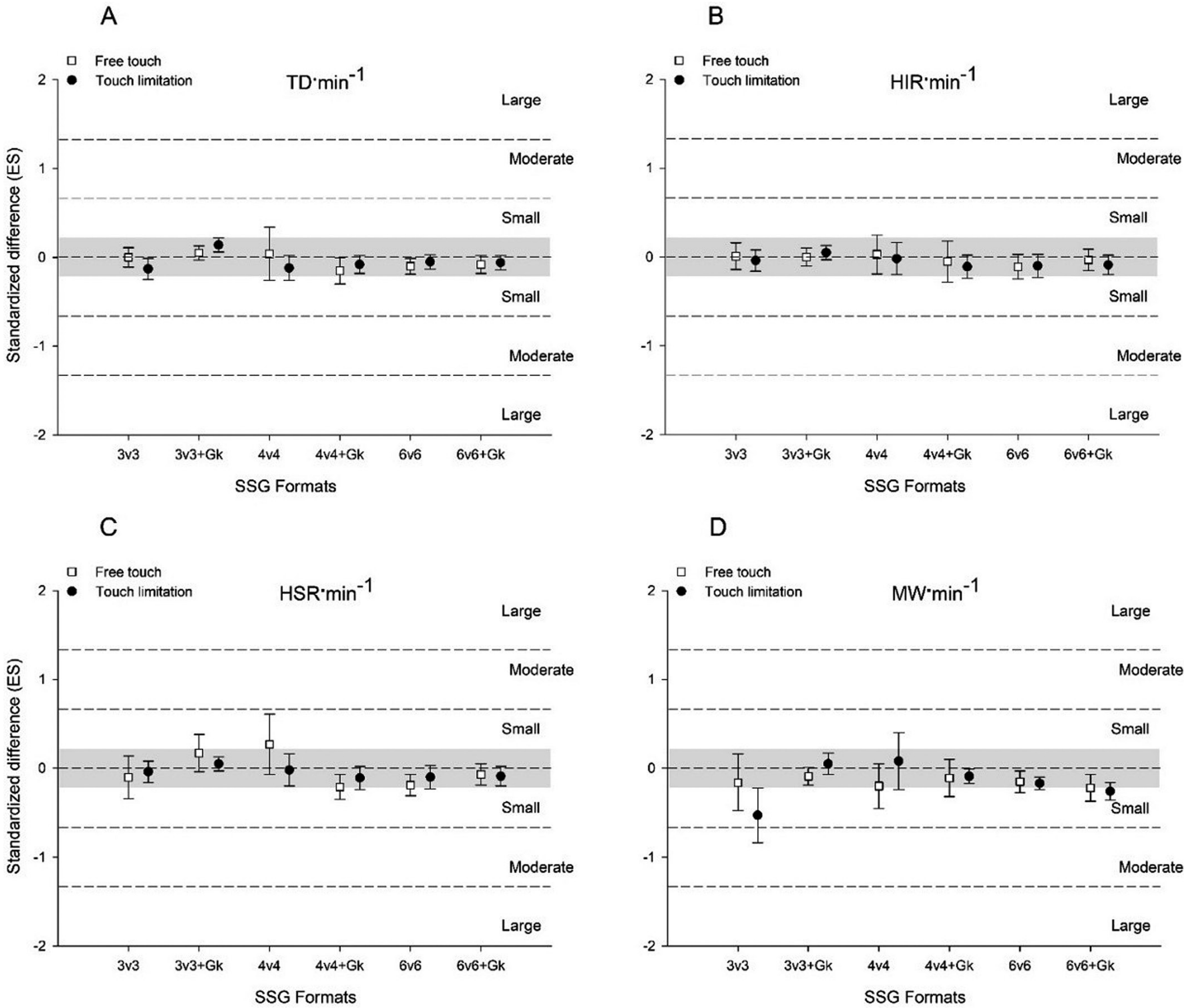

FIG. 2. Standardized comparison between different intervals across different small-sided game (SSG) formats with different task constraints.
Note. A) TD: total distance; B) HIR: high-intensity running (> 14.4 $km \cdot h^{-1}$); C) HSR: high-speed running (> 19.8 $km \cdot h^{-1}$); D) W: mechanical work (number of accelerations and decelerations > 2.2 $m \cdot s^{2}$); ES: effect size.

We observed that the ICC for $TD \cdot min^{-1}$ ranged from *high* to *nearly perfect* across different SSG formats (Tables 1 and 2). This result is in agreement with previous studies examining session-to-session variations in 3v3+Gk SSGs (ICC: 0.68) [24], 4-a-side indoor SSGs (ICC: 0.76) [22], and 6-a-side format SSG (ICC: 0.84; 0.89) [21, 23]. The CV of $TD \cdot min^{-1}$ ranged from 2.2 to 4.6% in all SSG formats (Tables 1 and 2). These values are in line with other studies that reported values of ~3–5% [10, 11, 21, 23, 24], but slightly lower than those reporting ~6–8% [6, 16, 22]. The higher CV values reported in other studies may be related to different influential factors, including the SSG format (< 3v3) [6], the type of technology used to capture the external load measure (GPS vs. video motion tracker) [22], and the experience level of the participants (amateur vs. professional) [16].

Our study showed a small standardized TE for $TD \cdot min^{-1}$ in almost all SSG formats (Figure 1/A), which is lower than the moderate effect reported by Clemente et al. [16], who examined the noise of the 5v5+Gk format. The slightly higher values of ICC (> 0.90) in some formats of our study, lower CVs (~2 to 4%), and lower standardized TE may be, in general, associated with the three-trial design adopted in this research, whereas many previous studies used two-trial designs [16, 21–24]. Increasing the number of trials reduces the noise in the monitoring variable [31].

The ICC of HIR·min^{-1} in this study ranged from *high* to *nearly perfect* across all SSG formats (Tables 1 and 2). This range is supported by the *large* to *very large* ICCs reported in the literature related to the noise of 3v3+Gk (ICC: 0.54) [24] and 6-a-side (ICC: 0.74; 0.78) [21, 23] SSGs. HIR·min^{-1} across selected SSGs showed CVs ranging from 7.2 to 16.4% (Tables 1 and 2). This range is similar to values reported in most previous studies (8.1 to 16.6%) [6, 21, 23] but lower than the values reported by Clemente et al. (CV: 54; 146%) [16]. HIR·min^{-1} also showed small standardized TE values in almost all SSG formats (Figure 1/B), which were lower than the moderate standardized TE values (ES: 0.83; 1.09) reported by Clemente et al. [16]. Such discrepancies may be explained by Clementine et al.'s use of a two-trial design and amateur participants [16], whereas our study used a three-trial design and professional soccer players.

HSR·min^{-1} had ICCs ranging from *moderate* to *nearly perfect* across different SSG formats in this study (Tables 1 and 2). Aquino et al. [21] observed a *very high* ICC value (0.78) when examining the noise of individualized high-speed running (> 60% of maximum speed) in a 6-a-side format. However, the wide range of ICCs for HSR·min^{-1} in this study is not surprising, given the variety of SSG formats and conditions employed. HSR·min^{-1} showed CVs between 12.2 and 29.4%, which is in agreement with some previous studies in which CV values ranged from ~26 to 33% [11]. However, this CV range is higher than the ~8% reported by Aquino et al. [21] and lower than the range of ~30–60% reported by other investigators [6, 10]. These differences might be related to the use of relative versus absolute thresholds [21], different SSG formats (< 3v3) [6], or the low sampling rate (1 Hz) of the GPS technology used [10] in previous studies.

MW·min^{-1} showed ICCs ranging from *moderate* to *very large* (0.47; 0.87) for all SSG formats (Tables 1 and 2). These results align with previous studies that reported *large* to *very large* values (0.66; 0.80) [21, 23, 24]. MW·min^{-1} also had CVs between 9.4 and 22.5% across different SSG formats. Previous studies have reported values of between 8.4 and 12.6% [6, 21, 23]. Almost all previous studies have used acceleration or deceleration measures separately, and these measures have been based on the distance covered, whereas we based this measure on the number of efforts [21, 23, 24]. Therefore, it is difficult to compare our results to those of previous studies.

Interestingly, across the games with the use of goalkeepers, the values of ICCs were similar irrespective of the conditions (formats and ball touch limitations). However, smaller values of ICC in games without goalkeepers were found when comparing the same external load measures. Thus, it seems that the use of goalkeepers may increase the reliability of external load measures and coaches may consider that for employing SSGS. However, it seems that the most important factor to justify weaker or stronger reliability is not the conditions used, but the intensity of the measure.

In our analysis of the differences between intervals across SSGs, almost all conditions showed *trivial* changes in the second interval, and only five out of 24 conditions revealed *small* standardized changes (Figure 2). *Trivial* changes were observed within intervals in almost all cases. This is in agreement with recent studies reporting *trivial* to *small* changes in the second interval [25, 26, 33]. Dellal et al. [25] showed a significant reduction from the first to fourth intervals (but not from the first to second intervals) in high- and *very high*-intensity activities (~-26; -37%). Therefore, based on our results, it seems that external load measures do not typically change substantially in the second interval. The reductions that do occur during SSGs are likely influenced primarily by other factors, such as training regimens compared to the interval set number *per se*. For instance, Clemente et al. [26] examined variations in external load within different intermittent regimens (6 × 3 min and 3 × 6 min). They found that longer intervals contribute to more substantial decreases in total distance, running distance, and total values of accelerations and decelerations.

This study had some limitations. Though our data were collected from a large number of sessions and conditions, our participant pool was small and represented only a single context. More consistent inferences could be drawn if more participants were involved. Additionally, interactions with readiness levels were not conducted. These interactions should be incorporated into future studies to identify associations between readiness levels and variations in physical demands. Finally, tactical behaviours were not analysed. Some external load measures are extremely dependent on players' behaviours, which, in turn, are highly dependent on playing circumstances. To account for this, future studies should establish a link between physical demand variability and tactical behaviour.

Despite its limitations, to the best of our knowledge, this research is the first examining the effects of ball touch limitations and the presence or absence of a goalkeeper on external load variability. Therefore, this work provides valuable new insights for coaches who regulate the design and application of SSGs.

As practical implications, we may highlight that higher noise levels observed in higher speed zones (e.g., high-speed running) in SSGs in the present study are likely associated with less occurrence of these activities compared to their lower speed zones during SSGs [33]. Sometimes practitioners target a specific neuromuscular external load GPS factor—such as high-speed running—to overload the hamstring muscles [34] in a consistent and stable (i.e., less noisy) way. In these cases, we recommend implementing supplemental running-based interventions (e.g., running-based high-intensity interval training) alongside SSGs [6, 35]. We also suggest prescribing a higher number of intervals to impose performance decrements on players due to fatigue as our study showed that the second interval is not sufficiently fatiguing.

CONCLUSIONS

Our study showed that the variability of total distance is lower than that of other external load measures. Thus, higher movement speed zones were associated with increased noise across all SSGs, irrespective of the game format and regimen. For almost all SSGs, no meaningful external load performance changes were observed in the second interval, suggesting that a drop in performance occurs only after a higher number of intervals. Touch limitations and goalkeeper presence had no meaningful effect on variability either. Hence, further studies involving other task constraints are recommended to help us better understand this area of research.

Acknowledgments

This work is funded by FCT/MCTES through national funds and when applicable co-funded EU funds under the project UIDB/EEA/50008/2020.

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