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Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes

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ABSTRACT: The aim of this study was to investigate the influence of the number of ball touches authorised per game (one touch [T1], two touches [T2], and free touches [FT]) on the players' physical responses throughout the bouts in 4 vs 4 soccer small-sided games (SSGs) with mini-goals (without a goalkeeper). Fourteen professional Polish players (age 23.2±2.7 years, height 177.9±6.1 cm, weight: 73.2±6.9 kg, body fat 12.6±2%, playing experience: 14±5 years) completed nine series of 4 vs 4 SSGs. Each trial included three series of SSGs with a game duration of 4 minutes on an equal sized pitch (30x24 m; 720 m^2; individual occupied area per player=90 m^2). Differences in physical responses and time-motion characteristics of players were measured with the Global Positioning System (GPS) and assessed using a repeated measures ANOVA to compare the three game conditions and the magnitude-based inference to evaluate the pairwise comparison effects. The results showed that only the variables distance covered at low speed, time walking, time at low speed, and accelerations of >4 m/s^2 were statistically significantly different among game conditions. The pairwise comparisons only identified significant effects for distance covered at low speed (between FT and T2), for time walking (between FT and T1), for time at moderate and low speed (between FT and T2), and for accelerations of >4 m/s^2 (between FT and T1). The players' performances are affected by the ball touch constraint during SSGs with mini-goals. The results provide useful information for training and task design that replicate specific physical demands (i.e., accelerations of >4 m/s^2, time walking or running at a lower speed).

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INTRODUCTION

Small-sided games (SSGs) are one of the most widespread soccer training drills that can be conducted among players of different ages and skill levels [1-4]. These tasks are used to improve both technical and tactical skills, and the fitness level of soccer players, as well as to shape their volitional features [5]. The intensity of the efforts implemented in the SSGs, both during actions with and without the ball, is very similar to what occurs in competitive games, where the players are forced to make decisions during conditions of increasing fatigue [6-8].

The nature of the effort performed during the SSGs can be modified by the aims of training sessions when changing some factors such as the number of players, the dimension of the pitch, playing and recovery time, coach involvement or encouragement (e.g., instruction or lack of it), or the playing rules (presence or absence of goalkeepers, playing with or without goals, and playing with a limited number of ball touches). Some recent reviews focussed on studies related to SSGs show that it is difficult to make accurate conclusions based on the influence of each of these factors in isolation [9, 10]. This is because of the lack of consistency in SSG designs according to players' fitness, age, ability, the level of the coach's encouragement, and the playing rules used during each experimental design. In particular, Aguilar [9] determined that there is a lack of studies on SSGs with mini-goals and their influence on the players' physical demands.

Some authors [11] studied different SSG formats and how their variations modified the players' physical demands. In particular, two oriented situations (with goalkeepers and regular goals and without goalkeepers but with mini-goals) and one non-oriented situation were analysed. The training intensity (i.e., average heart rate – HR_{mean}) in non-oriented and oriented SSGs with mini-goals was similar. However, the physical intensity was lower when the players performed regular goals with goalkeepers. This finding can be explained by the fact that when goalkeepers were included with the same pitch dimensions (25 m x 32 m) the players had less space for playing and showed lower HR_{mean} values.

The SSGs with mini-goals may suggest other task options that can be used to increase the physiological training load. For example, coaches and researchers simulate soccer-specific training drills using principles of play and a game model in the same task [12]. Obviously the SSGs with mini-goals must be considered with a training skill format, because they are not only adequate, but also better than the SSG (maintenance) format, combining excessive workload and an inadequate time for recovery (e.g., the goals are small). Thus, great shot accuracy is necessary and the players' finishing potential can be effectively improved. This procedure requires high-skilled responses when passing and shooting rather than a large quantity of shots (i.e. this is a determining factor of good attacking players) [13].

Due to the interaction between players' technical ability, tactical skills, and physical demands, the training practice may be more time-efficient if these three factors are closely combined and players are trained alongside each other in SSGs (i.e. concurrent training) [6]. Nevertheless, this training approach can be achieved merely with specific game formats (e.g., SSGs with mini-goals). To achieve this, periods of loading, recovery, and tapering have to be sensibly arranged.

On the other hand, possession play generally affects the players' physical and physiological responses, meaning that the game demands are higher [14]. The modification of the type of possession game can also influence the technical and physical demands of SSGs. Specifically, the inclusion of the T1 constraint may permit the players to play with less pass effectiveness and 1 on 1 duels and cover more distance, specifically with high-intensity runs and sprints [15,16]. In addition, when T2 were allowed during the SSG this condition generated higher high-intensity running and rating of perceived exertion (RPE) values [17]. Lastly, when FT were authorised the results did not reflect consistent findings for physical demands [17]. Accordingly, the coaching staff can manipulate the number of touches task constraint based on the need to develop the players' performance regarding technical and/or physical demands. A specific concern of SSGs with mini-goals is that the physical load imposed on players would be different through the modification of constraints of rules (e.g., limitation of ball touches). Previous investigations have shown the effect of the number of ball contacts within bouts of 4 vs 4 SSGs [18]. Despite this, to our knowledge, no study has assessed the effect of the number of ball contacts within 4 vs 4 SSGs (absence of mini-goals). In order to systematise the knowledge on this topic, previous studies have examined physical responses to SSGs (inclusion of goals). However, no available study was found focussed on the effect of these variables (i.e. players' physical and technical responses) during SSGs with mini-goals [9]. Therefore, the aim of this study was to examine acute physical responses when modifying the number of ball touches per player in the presence of mini-goals. It was hypothesised that the T1 SSGs with mini-goals would provide a more intense physical stimulus compared with T2 and FT respectively.

MATERIALS AND METHODS

Subject and sample

Fourteen professional outfield male soccer players, from a Polish professional football club, voluntarily participated in this investigation They had a mean ± SD age of 23.2 ± 2.7 years, height of 178 ± 6 cm, body mass of 73.2 ± 6.9 kg, body fat of 12.6 ± 2% and soccer experience of 14 ± 5 years. To obtain a homogeneous sample, only the players who played regularly in the official league games were considered for the study (i.e. the criteria for inclusion were: the player must have played more than 65 minutes of total playing time during the regular match). Goalkeepers were excluded from the sample, because they did not participate in the same physical training programme. All players were notified of the aims, requirements, benefits and risks of the study, before giving their written informed consent. All the research procedures were approved by the research ethics committee of the local university, in accordance with the latest version of the Declaration of Helsinki. The research also received formal approval from the club involved.

Research design

The SSGs consisted of 3 trials (a total of 9 repetitions of 4-min game situations), interspersed by 3 min of active recovery (for a total of 36 min of playing time). Each trial included three repetitions of 4 vs 4 SSGs with four mini-goals (without a goalkeeper, see Figure 1), with a game duration of 4 minutes. All the SSG repetitions were played and completed by the same 14 players under the same conditions during three sessions distributed over a 3-week time span during the second round of the in-season period. The number of ball touches (1 touch [T1], 2 touches [T2], and free touches [FT]) varied in each repetition of each trial, in a random order (the ball touch conditions were equally distributed during each trial, only varying in the randomised order). During the recovery period, participants went to a side of the pitch at walking speed to rehydrate (the players were allowed to take fluids ad libitum) and then returned to their position; however, these displacements were removed from the analysis because they did not replicate typical routines during a soccer match. The dimensions of the pitch area for the SSGs with mini-goals were 30 x 24; 720 m^2, individual occupied areas were selected to maintain a similar relative pitch area per player (90 m^2 per player, see Figure 1). The SSGs were conducted on the same outdoor artificial grass pitch at the home training venue of the club. All the game situations were performed on an outdoor artificial grass pitch with normal mini-goals, and participants wore official clothing and soccer boots. In all the experimental situations, participants were encouraged to score the highest number of goals during the game. There was no presence of a goalkeeper per side. The verbal encouragement throughout all the SSG situations was also standardised by the technical staff (head coach and assistants) with the help of the experimenters, to maintain a high skill level. Players had been familiarised with the SSG with mini-goals formats and regimes during previous training sessions in the season. The SSGs were performed at the beginning of training to ensure that players were not exhausted. Each session began with the same 20-minute period of general movement patterns, specific movement patterns with ball, specific movement patterns without ball (see [19]), followed by the same soccer-specific passing game, which lasted another 10 minutes. Both teams in the SSGs were encouraged to score the highest number of goals in the time delimited. In order to avoid stoppage time to a maximum extent in the games, several balls were located around playing areas for immediate availability. Additionally, there were two assistant coaches outside the playing area to ensure continuous play. The two assistant coaches acted as timers and referees (i.e., to enforce the rules of each SSG: T1, T2, FT for each ball involvement). To limit the influence of hydration status on the variables analysed, all participants were advised to maintain their normal diet, greater focus being placed on high consumption of water and carbohydrates (50-60% of total energy intake) [20], to avoid the effects of dehydration [21].

Data collection

The physical responses, and time-motion characteristics of players, were monitored using Global Positioning System devices (GPS MinimaxX v4.0, Catapult Innovations, Melbourne, Australia) operating at a sampling frequency of 10 Hz, and incorporating a 100 Hz triaxial accelerometer. This technology has been previously validated, and has been proven reliable for monitoring movements and activities of different intensities of soccer players [22-24]. The device was fitted to the upper back of each player, using the manufacturer-designed harness. The devices were activated 15 min before the start of each training session, in accordance with the manufacturer's instructions.

According to the available research [22-24], and by a priori importance for performance in soccer, the following variables were assessed: player load (an estimate of physical demand, combining the instantaneous rate of change in acceleration in three planes: forward/backward X, side/side Y, and up/down Z; for details, see [25]); exertion index (an index calculated based on the sum of a weighted instantaneous speed: a weighted accumulated speed over 10 s, and a weighted accumulated speed over 60 s (for details, see [26]); maximum velocity reached (m/s); total distance covered (m); distance covered at different thresholds/zones (m); time spent at different intensities (%); and the distance covered with different acceleration bands (m). Similarly to previous studies [27-29], intensity was classified in seven speed zones of players' movements: standing (≤ 1.67 m/s), walking (> 1.67 m/s, ≤ 2.22 m/s), jogging (> 2.22 m/s, ≤ 3.33 m/s), low-speed running (> 3.33 m/s, ≤ 4.17 m/s), moderate-speed running (> 4.17 m/s, ≤ 5 m/s), high-speed running (>5 m/s, ≤ 6.94 m/s), and sprinting (> 6.94 m/s). The rate of acceleration variables can be pre-set within a minimum range modification of 0.5 s, with at least a 0.5 ms^2, and maximum acceleration was required to consider an acceleration activity [30]. This was measured on the basis of the change in GPS speed data.

Despite previous categories used during match analysis [31, 32], new outcomes have shown substantial constancy in running metabolic cost at speeds ranging from -2 to +2-2 m/s^2 [33]. Therefore, we decided only to analyse those changes >2 m/s^2, and ±-2 m/s^2, in acceleration and deceleration, respectively. The following categories were clearly established: moderate deceleration (MD) was from -2 to -3-2 m/s^2; high deceleration (HD) was <-3-2 m/s^2; moderate acceleration (MA) was from 2 to 3-2 m/s^2; and high acceleration (HA) was >3-2 m/s^2 [32]. The intensity of standing generated no distance measurement, so it was incorporated into walking. Due to the fact that there was not enough space in SSGs for the players to reach sprinting speed, the values recorded in this category were very low. Hence, they were combined with the high-speed running category. The acceleration bands were divided into the following 6 categories: acceleration 1 (<-4 m/s^2), acceleration 2 (-4 to -2 m/s^2), acceleration 3 (-2 to 0 m/s^2), acceleration 4 (0-2 m/s^2), acceleration 5 (2 to 4 m/s^2), and acceleration 6 (>4 m/s^2).

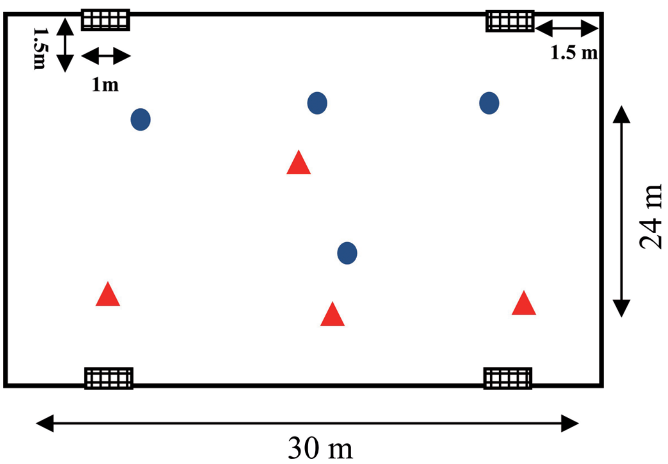

FIG. 1. Pitch size (i.e., 30 x 24 m^2, individual occupied area per player = 90 m^2).

Statistical analysis

The physical responses and time-motion characteristics of the players, playing according to the three different rules (i.e., 1-touch [T1], 2-touch [T2], and free touches [FT], for each ball involvement) in the same format of training (4 vs 4 SSGs with 4 mini-goals), were compared using a repeated measures ANOVA. Afterwards, in order to test all the pairwise comparisons between the game formats, the magnitude-based inference method with repeated measurements was applied. Statistical analyses were performed using SPSS 22.0

(IBM Corp., Armonk, NY, USA) and the level of significance was set at p≤ 0.05.

The pairwise comparisons for each variable were calculated with a Hopkins spreadsheet [33-34] that computes the standardised Cohen's *d* values (adjusted effect size). The thresholds for the effect size (ES) statistics were 0.2= trivial, 0.6 = small, 1.2 = moderate, 2.0 = large, and >2.0 = very large effect. Mechanistic magnitude-based inferences were assessed using the smallest worthwhile difference. The smallest worthwhile difference was calculated by 0.2 times the standardisation, estimated from the between-subject standard deviation. Differences were defined as unclear if the confidence intervals for the difference in the means included substantial positive and negative values (±0.2*standardisation) simultaneously [35]. Magnitudes of clear differences were assessed as follows: >0.25%, trivial; 0.25%–75%, possible; 75%–95%, likely; 95%–99%, very likely; >99% [36].

RESULTS

Table 1 shows the descriptive statistics for each variable according to the game conditions (T1, T2, and FT) and the mean differences between conditions. The results of the repeated measures ANOVA showed that only the variables distance covered at low speed (F=8.151; p=0.007), time walking (F=3.181; p=0.043), time at moderate (F=4.4751; p=0.0127) and low speed (F=4.770; p=0.036), and acceleration 6 (F=4.343; p=0.014) were statistically significantly different among game conditions.

TABLE 1. Descriptive statistics of physical responses of players in the SSGs according to the number of touches (T1, T2 and FT).

Variable	T1	T2	FT	T2-T1	FT-T2	FT-T1	ANOVA
	M ± SD	M ± SD	M ± SD	Difference (%); ± 90%CL	Difference (%); ± 90%CL	Difference (%); ± 90%CL	P
Indicator of workload							
Player Load	39.7 ± 8.5	46.6 ± 10	40.2 ± 9.5	6.9; ± 4.3	-6.4; ± 3.5	0.5; ± 4.6	0.106
Exertion Index	2.9 ± 0.8	3.1 ± 1.1	3.0 ± 1.0	0.2; ± 6.7	-0.1; ± 4.7	0.1; ± 6.9	0.163
Maxima Velocity(m/s)	5.2 ± 0.7	5.1 ± 0.7	5.2 ± 0.7	-0.13; ± 2.8	0.1;± 5.7	-0.1; ± 6.0	0.293
Distance covered rate (m/s)							
Total Distance	394 ± 70	411 ± 84	396 ± 78	16.8; ± 3.4	-14.4; ± 2.1	2.4; ± 3.7	0.326
Distance Walking	207 ± 20	204 ± 25	197 ± 19	-3.0; ± 3.4	-6.8; ± 3.5	-9.8; ± 2.7	0.477
Distance Jogging	102 ± 37	116 ± 44	111 ± 47	13.3; ± 9.1	-4.3; ± 7.6	9.0; ± 12.8	0.207
Distance Low-speed	48.4 ± 23.3	52.6 ± 29.6	49.9 ± 22.4	4.2; ± 16.6	-2.7; ± 9.6	1.5; ± 13.1	0.007**
Distance Moderate-speed	22.6 ± 14.4	25.4 ± 19.0	23.5 ± 14.7	2.8; ± 5.3	-1.9; ± 5.1	0.9; ± 4.6	0.189
Distance High-speed	8.8 ± 8.3	7.6 ± 8.5	8.7 ± 10.2	-1.2; ± 2.8	1.1; ± 2.8	-0.1; ± 3.3	0.412
Time (%)							
Time Standing	9.0 ± 5.5	8.5 ± 6.3	10.2 ± 6.6	-0.5; ± 16.1	1.7; ± 18.4	1.2; ± 23.2	0.355
Time Walking	67.4 ± 5.8	65.2 ± 7.5	64.5 ± 6.3	-2.2; ± 2.9	-0.7; ± 3.0	-2.9; ± 2.2	0.043*
Time Jogging	15.0 ± 5.3	17.0 ± 6.2	16.4 ± 6.6	2.0; ± 9.8	-0.6; ± 8.5	1.4; ± 12.3	0.178
Time Low-speed	5.4 ± 2.6	5.9 ± 3.3	5.6 ± 2.5	0.5; ± 16.5	-0.3; ± 10.1	0.2; ± 13.9	0.036*
Time Moderate-speed	1.9 ± 1.4	2.4 ± 1.8	2.1 ± 1.4	2.8; ± 21.6	-7.9; ± 18.7	0.2; ± 18.5	0.012*
Time High-speed	0.6 ± 0.7	0.5 ± 0.7	0.6 ± 0.8	-0.1; ± 2.8	0.1; ± 2.8	0.0; ± 3.3	0.369
Acceleration (numbered)							
Distance Acc. 1	1.6 ± 1.0	1.5 ± 1.2	1.5 ± 1.0	-0.1; ± 14.5	0.0; ± 24.2	-0.1; ± 18.0	0.401
Distance Acc. 2	10.4 ± 3.3	10.6 ± 4.2	10.0 ± 3.3	0.2; ±12.5	-0.6; ± 12.6	-0.4; ± 6.2	0.468
Distance Acc. 3	130 ± 22	133 ± 26	131 ± 25	0.3; ± 4.1	-2.1; ± 4.2	0.9; ± 4.1	0.378
Distance Acc. 4	212 ± 40	226 ± 47	219 ± 44	14.0; ± 3.8	-7.6; ± 2.6	6.8; ± 4.2	0.194
Distance Acc. 5	13.3 ± 3.8	14.0 ± 4.0	13.0 ± 3.8	0.7; ± 7.1	-1.1; ± 9.2	-0.4; ± 8.0	0.153
Distance Acc. 6	3.9 ± 1.4	3.3 ± 1.4	3.3 ± 1.4	-0.4; ± 10.5	0.0; ± 18.5	-0.6; ± 17.7	0.014*

*p<0.05; **p<0.01

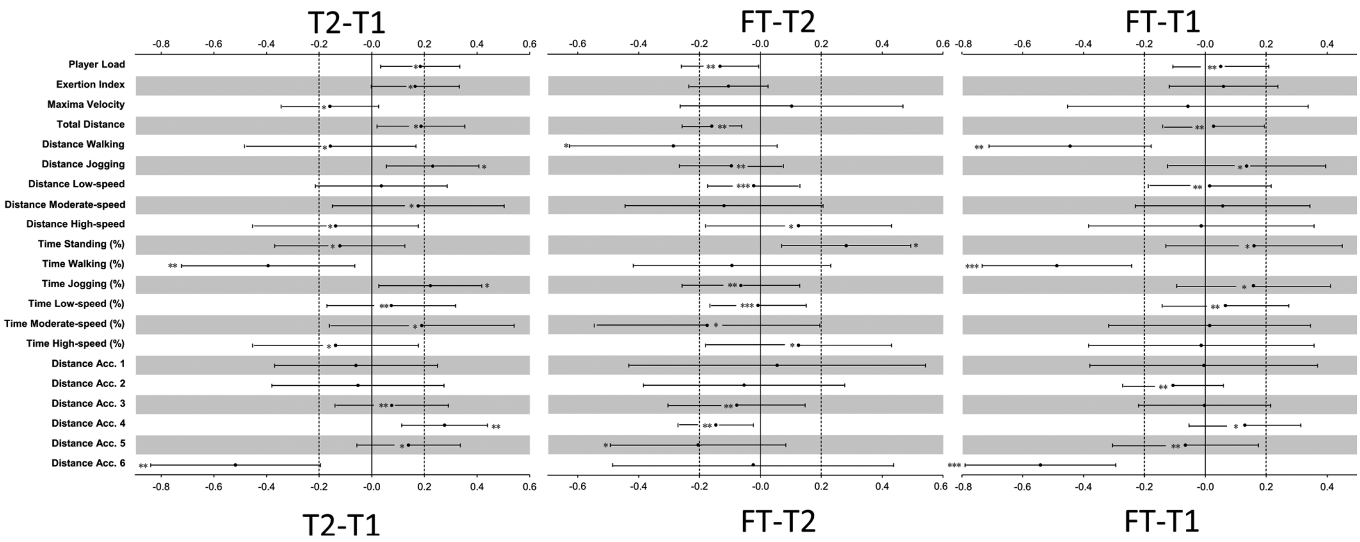

FIG. 2. Compared by the method of magnitude-based inferences with repeated measurements.

Figure 2 shows the results of the pairwise comparisons and their effects (magnitude-based inference method). Significant effects were only identified among SSGs with mini-goals (ball touch restrictions of T1, T2, and FT) for distance covered at low speed (likely effects between FT and T2: greater distance covered during T2), for time walking (likely effects between FT and T1: more time walking with T1), for time at moderate speed (possible effects between FT and T2: more time at moderate speed during T2), for time at low speed (likely effects between FT and T2: more time at low speed during T2), and for acceleration of >4 m/s^2 (likely effects between FT and T1: more distance covered at acceleration 6 during T1).

DISCUSSION

This experimental study sought to examine the influence of the number of ball touches authorised per game (one touch [T1], two touches [T2], and free touches [FT]) on the physical response of professional players throughout the bouts in 4 vs 4 soccer SSGs with mini-goals. On the one hand, the key findings reflect that during SSGs played with T1 the players performed their highest intensity of exercise (acceleration of >4 m/s^2) and time walking. These contradictory results may be explained by the influence of the pitch dimensions of 4 vs 4 SSGs. These tasks meant that the players increased the number of accelerations and decelerations in shorter distances with high-intensity movements [36-37]. Then, the players covered less distances but with greater effort [38]. The results are in accordance with the available research that identified more turnovers and missed passes and fewer 1-on-1 situations during T1 SSGs [37,38]. In fact, this type of SSG increases intermittent efforts and then produces higher lactate concentrations [18], improving anaerobic performance.

On the other hand, greater distances covered at lower velocities (moderate and low speed) occur during T2 play. These findings have been partly confirmed by Mallo and Navarro [39], who noted an increase in distance covered by players at different velocities, in relation to the increasing number of touches during play, which was focussed on two neutral players keeping the ball. Specifically, the T2 SSGs allow contacting the ball before passing or kicking the ball or after dribbling, so the players' actions are of lower intensity compared with T1. Accordingly, players' decision making and quick responses characterise the T1, but T2 implies more time to decide, act and react during the games. Therefore, the T2 SSGs may involve greater distances covered at different intensities, higher RPE values and aerobic performances due to better passing effectiveness, lower game pace and more ball possession duration [37]. In particular, Rebelo et al. [40] identified, when analysing 4 vs 4 SSGs, that this game was highly demanding in relation to repetitions and fatigue development in muscle power-based actions compared to other SSG formats with larger pitches and greater numbers of players such as 8 vs 8 games. However, the present results are different from those reported by Dellal et al. [17-18], who found higher RPE and high-intensity running during T2 SSGs and FT.

Our research highlights the fact that the modification of the number of ball touches during SSGs could be a useful task constraint in order to permit and improve the players' physical responses (i.e., repetitions and muscle-power actions). It seems that SSGs, in the format of 4 vs 4 with mini-goals, are a very favourable training task that facilitates the effective development of players' fitness, while concurrently improving their technical and tactical abilities. The current findings might help individuals involved in the physical preparation of players (e.g. technical coaches, fitness coaches, and sports science staff) when developing training programmes and training sessions in line with the use of one, two or free touches playing SSGs with mini-goals, and with the levels of high-speed accelerations targeted to reach during specific training drills. In addition, this rule modification allows one to reduce or increase the fatigue induced to elicit adaptations related to physical performance.

Indeed, situations regarding mini-goals using T2 or FT could be used for recovery (i.e. less action at high intensity and more time spent in low or moderate sided games) and T1 during competitive and impact microcycles (i.e., intermittent efforts with accelerations, decelerations and walking actions).

Despite the results, there are several limitations to the current research that should be considered in further studies concerning players' physical demands and the use of GPS devices. Firstly, recent available literature showed that <15 Hz is not reliable (see [41]) when analysing SSG conditions. Secondly, the margins of victory (i.e., goal differences between teams) during SSGs were not accounted for in the present study; thus future research should assess the impact of the match/game status (winning, drawing or losing) on the physical and technical-tactical performance [42]. Finally, the findings were in line with the principle of specificity that justifies the use of SSGs during training sessions [43]. Specifically, it is a regular practice in professional and semi-professional soccer to have SSGs and weekly friendly matches (FMs) during the training week [43]. For this reason, future studies should compare the performance variation between the physical responses during official matches, friendly matches and SSGs with mini-goals.

CONCLUSIONS

In conclusion, this research improves the understanding of some of the physical responses affecting SSG intensity when using mini-goals. The number of touches during SSGs influenced the players' performances. The results pointed out two important issues for coaching staff when designing and controlling for training tasks. On the one hand, the use of one touch during SSGs increases the time walking and high-intensity accelerations (acceleration of >4 m/s^2). This fact may lead coaches to design training plans close to competitive situations during a match (i.e., passing with a high defensive pressure without time to control the ball or anticipating quick responses for each playing position during the SSG, improving the tactical and technical skills). In addition, these task conditions can be used during between-match microcycles in order to prepare the players' physical fitness for specific competition demands. On the other hand, with the use of two touches during SSGs the players covered a greater distance at low intensity and spent more time at low and intermediate intensity. These conditions reinforce the importance of developing training tasks focused on recovery after high-intensity matches, congested fixture periods or during post-season training. Accordingly, the purpose of coaches using two touches during SSGs can be to perform at moderate physical intensity, focusing the players' attention on tactical requirements such as players' positioning, open spaces, decision making for each playing position or offensive and defensive strategies in small-sided game contexts (4 vs 4 SSG). Therefore, the results highlight the importance of the ball touch constraint during SSGs with mini-goals, and provide useful information for training and task design that replicate specific physical demands of elite football players.

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