

EFFECT OF BOUT DURATION ON EXERCISE INTENSITY AND TECHNICAL PERFORMANCE OF SMALL-SIDED GAMES IN SOCCER

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ABSTRACT

Fanchini, M, Azzalin, A, Castagna, C, Schena, F, McCall, A, and Impellizzeri, FM. Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer *J Strength Cond Res* 24(X): 000–000, 2010—To examine whether the increase in bout duration would affect the exercise intensity and technical actions, we manipulated bout duration during a typical small-sided game drill (SSG) in male soccer players. Nineteen players (mean \pm SD: age 24 ± 4 years, body mass 74 ± 4 kg, and height 180 ± 5 cm) completed three bouts of a 3-a-side drill at three different bout durations: 2, 4, and 6 minutes. Exercise intensity was quantified using heart rate (HR) and rating of perceived exertion (RPE). A nonsignificant duration \times bout interaction was found for HR ($p = 0.757$). Heart rates of bout 1 were significantly lower than bout 2 ($p = 0.004$) and bout 3 ($p = 0.049$). The effect of duration was close to significance for HR ($p = 0.057$) with 6-minute SSG significantly lower than 4-minute SSG ($p = 0.004$). Duration \times bout interaction did not reach the significance for RPE ($p = 0.096$). The RPE significantly increased along the bouts ($p < 0.001$) but was not affected by duration ($p = 0.763$). No effect of duration was found for number of technical actions per minute ($p > 0.111$). A significant effect of bout was only found for successful passes ($p = 0.018$). Partially confirming our hypothesis, the increase in bout duration from 2 to 6 minutes resulted in a decrease in intensity only between the 4- and 6-min SSG. However, duration did not influence the technical actions and proficiency. The magnitude of changes in HR (89.5 vs. 87.8 of maximum) is probably not enough to induce different

training adaptations. Therefore, coaches can use different bout durations with minimal impact on exercise intensity and without compromising technical proficiency.

KEY WORDS specific training, football, time, heart rate, technical skills

INTRODUCTION

Aerobic fitness is a well-established physical component for soccer players (14). Interval training using small-sided games (SSG) has been shown to be effective for improving aerobic fitness and soccer-specific endurance (13), and the use of this form of specific training has attracted the interest of most sport scientists (6–8,13,16,18–20,22). Because the training adaptations are induced by the physiological stress imposed on the athletes (15), exercise intensity is considered one of the key variables influencing the training response (10). For this reason, a growing number of studies have recently examined the effects of several factors (number of players, pitch dimensions, and coach encouragement) on the exercise intensity of SSG (1,18,22). A further factor commonly manipulated by coaches to vary the exercise intensity is bout duration, but this has not yet been investigated.

Although previous studies have examined the effect of manipulating various factors on the physiological load imposed by these soccer-specific exercises, few studies have reported the technical score of SSG (16,17), and no investigations have examined the effects of varying external factors on technical components. This is unfortunate, because several coaches are interested in the technical characteristics of SSG other than exercise intensity. Understanding the effect of varying external factors on both exercise intensity and technical scores would allow a better integration of SSG within the whole soccer training process that includes both physical and technical training. Indeed, the manipulation of exercise intensity may also elicit changes in the quality and quantity of technical components that can be different from

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those planned by the coach. Therefore, from this perspective, it is also important to understand how duration affects the amount and the quality of technical components.

In endurance sports, exercise intensity changes according to exercise bout duration. However, SSGs are characterized by intermittent and spontaneous activities, and as a result, the pace is not dictated by the coach but rather is self-chosen by players. By increasing the bout duration, the players may adopt a sparing behavior thus decreasing the average intensity. Alternatively, the intensity may decrease simply as a consequence of fatigue. Therefore, we hypothesized that, by increasing bout duration, exercise intensity would decrease. Because recent studies (23) have shown that previous exercise and muscle fatigue can decrease the technical proficiency, we also hypothesized that for the increase in bout duration would result in a decrease in technical proficiency. To test this hypothesis, we varied the bout duration during an SSG drill to examine the effect on exercise intensity and technical actions.

METHODS

Experimental Approach to the Problem

To examine the effect of an independent variable on a dependent variable, the other factors must be kept constant or controlled, as recently done by Kelly and Drust (18) to examine the effect of pitch dimension, or by Rampinini et al. (22) who used a factorial design to examine the effect of coach encouragement, pitch dimension, and SSG formats on exercise intensity. Therefore, following the same approach, the effect of bout duration (independent variable) on exercise intensity and technical actions (dependent variables) were verified by manipulating the duration while keeping, pitch dimension, number of players, recovery time, and the game rules constant. The reliability of heart rate (HR) during SSG range from 2.0 to 2.4% (typical error) (22), whereas the reliability of technical actions have been recently reported to be $k = 0.82$ (18).

Subjects

Nineteen male amateur and professional soccer players (mean \pm SDs: age 24 ± 4 years, body mass 74 ± 4 kg, and height 180 ± 5 cm) of 2 different teams took part in the study. The two teams trained 7 days a week. Training consisted mainly of specific and generic interval training (13), and repeated-sprint ability sessions (4). Before participating, all subjects gave their written informed consent. The study was approved by the local Ethics Committee.

Procedures

Before the data collection, players completed the Yo-Yo Intermittent Recovery Test Level 1 to determine the maximal heart rate (HR_{max}) (2). Players completed in a random order a series of 3 bouts of 3-a-side SSG of different duration (2, 4, and 6 minutes) interspersed by 4 minutes of active recovery. The field dimension (37×31 m; 191 m^2 per player), the recovery between bouts, and the rules were kept constant.

TABLE 1. Average exercise intensity (% of maximal heart rate) including the first minute.

	2-min duration		4-min duration		6-min duration		Pooled data	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bout 1	82.2	3.7	85.8	3.6	85.2	3.6	84.4	3.9
Bout 2	82.4	4.7	85.5	4.5	86.3	3.3	84.8	4.5
Bout 3	82.5	4.0	86.3	3.2	85.4	3.3	84.7	3.8
Pooled	82.4	4.1	85.9	4.1	85.6	3.9		

The 3-a-side was performed with goalkeepers, 2 touches and with the ball always available by prompt replacement when hit out of play. Goalkeepers were not allowed to take the ball with their hands. Coach encouragement was also provided (22). SSGs were completed after 20-minute warm-up consisting of running, striding, dribbling, and passing. The SSGs were performed during the preseason training period (August to September).

During the SSG, HRs were collected using a long-range telemetry system (Suunto t6 Team Pack Pro, Suunto Team Pod, Suunto Oy, Finland) that enabled real-time exercise-intensity checking. Data were recorded every second. To account for HR ramp at the beginning of SSG bouts, HR data were analyzed excluding the first minute of exercise (12). Exercise intensity was also quantified using the rating of perceived exertion (RPE) measured with the CR-10 Borg's scale (3). At the end of each SSG bout, players were asked to rate their perceived exertion using standardized instruction and anchor procedures. Specifically, the players were asked to rate the exertion they perceived during the bout. Players were already well familiarized with the CR-10 before the commencement of the study.

TABLE 2. Average exercise intensity (% of maximal heart rate) excluding the first minute.

	2-min duration		4-min duration		6-min duration		Pooled data	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bout 1	88.0	3.4	88.9	3.4	87.3	3.5	88.1	3.4*
Bout 2	88.7	3.2	89.7	3.1	88.5	3.3	89.0	3.2†
Bout 3	88.8	2.9	89.9	2.5	87.7	3.2	88.8	3.0*
Pooled	88.5	3.2	89.5	3.1	87.8	2.8‡		

* $p = 0.049$ lower than bout 3.
 † $p = 0.004$ higher than bout 1.
 ‡ $p = 0.004$ lower than 4 minutes.

All SSGs were videorecorded using a digital video camcorder (Canon MV700, miniDV, Canon Japan) positioned on a tripod. The technical actions of each player were counted and classified into 10 categories: pass, successful pass, unsuccessful pass, tackle, header, turn, interception, dribbling, shoot, and shoot on target. We considered a “turn” as a change of direction with the ball greater than 90°. Two operators completed the notational analysis using the videorecording on 2 occasions. The median value of the 4 measurements was used for the analysis. To normalize the data for the different durations, the individual technical actions were expressed as the number of actions per minute ($n \cdot \text{min}^{-1}$)(5).

Statistical Analyses

Data are presented as mean \pm SDs. The assumption of normality was verified using the Shapiro–Wilk *W* test. The effect of bout and duration (independent variables) on HR and RPE (dependent variables) was examined using a fully repeated 2-way analysis of variance with the factor bout with 3 levels (bout 1, bout 2, and bout 3), and factor duration with 3 levels (2, 4, and 6 minutes). When a significant *F*-value was found, the Bonferroni post hoc test was applied. Effect size (partial eta squared, η^2) was also calculated, and values of 0.01, 0.06, and above 0.15 were considered small, medium, and large, respectively. The effects of duration and bouts (independent variables) on technical score (dependent variables) were examined separately using a nonparametric test (Friedman’s test). The level of significance was set at $p \leq 0.05$.

RESULTS

Exercise Intensity

The HR_{max} reached during the Yo-Yo Intermittent Recovery Test was $196 \pm 9 \text{ b} \cdot \text{min}^{-1}$, and the total distance covered was $1,855 \pm 371 \text{ m}$. Because the subjects involved in this study were amateur and subelite professional players, their fitness level is as expected between 1,810 m reported in the literature for “moderately trained soccer players” and 2,030 m for “subelite players” (2). The average HR values of each bout including the first minute (Table 1) are lower ($p < 0.001$) than the values calculated excluding the first minute (Table 2).

The duration \times bout interaction for HR was not significant ($p = 0.757$, $\eta^2 = 0.026$). A significant main factor bout was found ($p = 0.016$, $\eta^2 = 0.205$)

TABLE 3. RPE of the small-sided games assessed using the category ratio 0–10 scale.*

	2-min duration		4-min duration		6-min duration		Pooled data	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Bout 1	6.3	1.4	6.2	1.4	6.1	1.6	6.2	1.5†
Bout 2	6.7	1.5	6.9	1.3	6.8	1.4	6.8	1.4†
Bout 3	7.2	1.9	7.3	1.5	7.5	1.4	7.3	1.6†
Pooled	6.7	1.6	6.8	1.4	6.8	1.5		

*RPE = rating of perceived exertion.
†All different from each other, $p < 0.001$.

with post hoc analysis showing that the mean HR of bout 1 was lower than of bout 2 ($p = 0.049$) and bout 3 ($p = 0.004$). The main factor duration was close to significance ($p = 0.057$, $\eta^2 = 0.147$), but only the mean HR of the 6-minute SSG was significantly lower than the 4-minute SSG ($p = 0.004$). The effect sizes of the main factors were large (close to or higher than 0.15).

Data for 1 subject were not available. Therefore, the following analysis has been performed on 18 players. The duration \times bout interaction for RPE was not significant ($p = 0.096$, $\eta^2 = 0.115$). The significant main factor for bout was found ($p < 0.001$, $\eta^2 = 0.733$) with post hoc analysis showing that the RPE of every bout was different from each other.

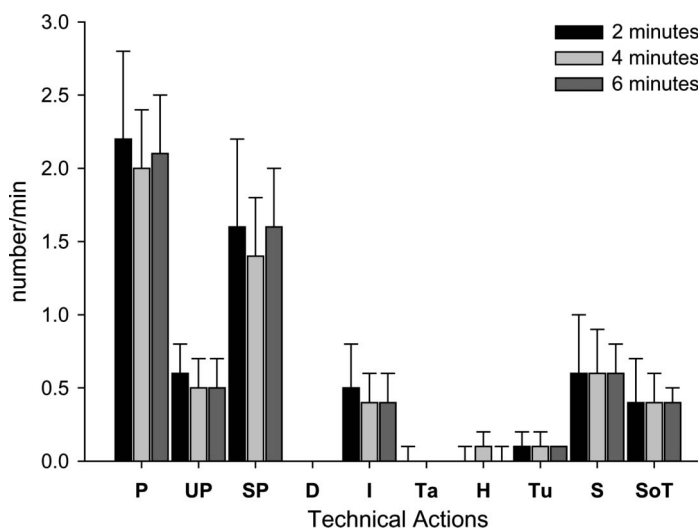
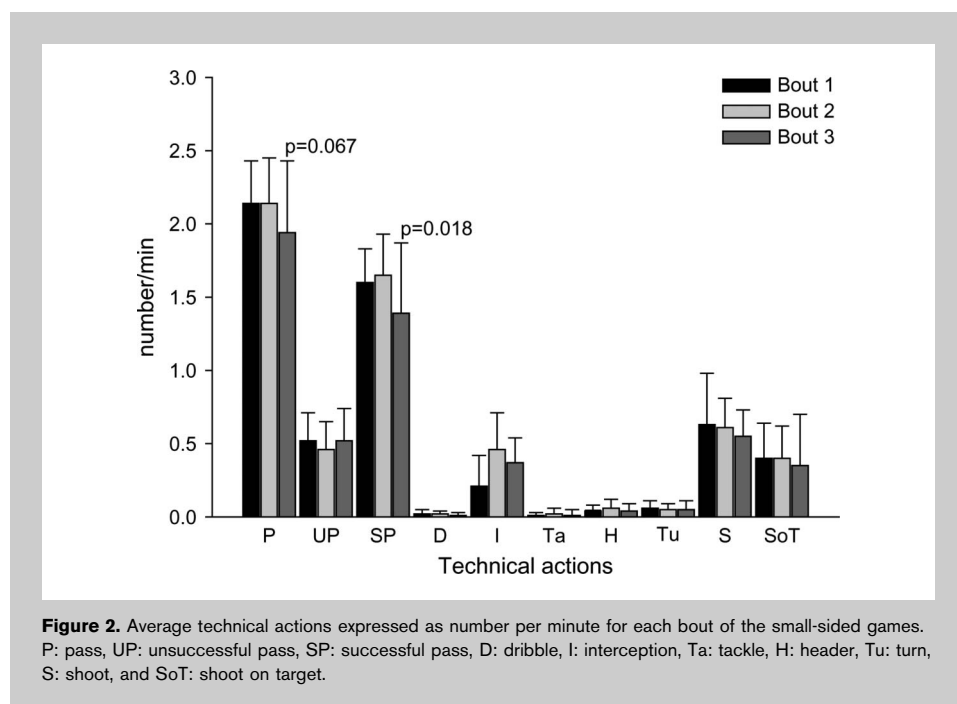


Figure 1. Average technical actions expressed as number per minute of the small-sided games completed at different bout durations (2, 4, and 6 minutes) P: Pass, UP: unsuccessful pass, SP: successful pass, D: dribbling, I: interception, Ta: tackle, H: header, Tu: turn, S: shoot, and SoT: shoot on target.



The main factor for duration was not significant ($p = 0.763$, $\eta^2 = 0.016$; Table 3).

Technical Performance

No effect of duration was found in any of the technical actions ($0.111 < p < 1.000$; Figure 1). Bout number had a significant effect on successful passes that decreased in bout 3 ($p = 0.018$), and on total passes that also tended to decrease in bout 3 ($p = 0.067$; Figure 2).

DISCUSSION

Small-sided games are commonly used as a specific training modality for enhancing the aerobic fitness of the players (13,19,22). Given the importance of internal training load (i.e., actual physiological stimulus) in inducing training adaptations (10,15), several studies have examined how to manipulate the intensity of SSG to use this specific exercise during physical training to achieve intensities sufficient to improve aerobic fitness. Although in the literature, studies have examined the effect of various extrinsic factors on exercise intensity (18,22), no investigations have verified the effect of manipulating duration. The main finding of this study is that by increasing the duration from 2 to 6 minutes, there was a decrease in exercise intensity for the longer duration (6-minute SSG) but no effect on technical actions. The change in HR, however, does not appear to be substantial in terms of affecting the potential for training adaptations.

The 3-a-side used in the present study is a commonly used SSG format for soccer training and we adopted rules

frequently used in training (2 touches of the ball for each player, coach encouragement, and goalkeepers). Previous studies have examined 3-a-side with durations of 3–5 minutes reporting intensities similar to that found in the present study with HR ranging from 87.9 to 91.3 of HR_{max} (6,19–22). Contrary to our hypothesis, we did not find a decrease in exercise intensity with increase in the duration. Indeed, we found a slight nonsignificant increase in HR between the 2 and 4-minute duration, and a decrease in HR for the 6 minutes only. This may be because of time needed to “enter in the match.” The decrease in HR found for the 6-minute SSG may indicate the occurrence of fatigue. Unfortunately, we were

not able to measure the distance covered at various running speeds (11,21), and therefore future studies should investigate if there is a concomitant decrease in the external load when increasing duration above 4 minutes. It may be possible that by further increasing the duration, the drop in HR would be even more evident. However, we decided not to use longer bouts because these are unusual in soccer training. A significant increase in HR was found across bouts, similarly to that reported by Kelly and Drust (18). Overall, these findings seem to suggest that 4-minute bouts are the best choice in terms of exercise intensity because the HR is high, and the duration of the physiological stimulus is long enough to elicit training adaptations (13). However, as already underlined in a previous study (22), the absolute HR variations were 1–2% of HR_{max} , and therefore, the physiological importance of these changes may be relatively low. Nevertheless, these findings are important from a methodological point of view because they confirm that the duration must be taken into account when comparing SSGs of different durations.

The RPE changed significantly between bouts but was not affected by duration. This may be because of an increase in the perception of the effort caused by increasing the duration despite a slight decrease in HR for the 6-minute SSG. The perceived exertion was lower than that reported by Rampinini et al. (22) probably because of differences in rules, pitch dimensions, and number of players. These findings have a practical usefulness, because the perceived exertion may influence the acceptability of the exercise, and therefore, the coach should consider whether or not to

increase the duration given this may have an impact of the perception of effort.

Although previous studies have examined the exercise intensity of SSG, few investigations have verified the effect of various factors on technical actions (16,18). Given that SSGs are commonly used as a training modality for involving both physical and technical components and that several coaches use SSG especially for technical purposes, the examination of the effect of duration on technical actions is important. In the present study, technical actions were not influenced by duration, and only few technical abilities tended to decrease across bouts. Specifically, although we cannot exclude type I errors given the multiple tests, we found a decrease in passes, successful passes, and interceptions in the third bout indicating a decrease in technical proficiency. Interestingly, passing is also a technical ability recently shown to be influenced by previous exercise (23). The findings of this study are slightly different to those reported in a recent paper by Kelly and Drust (18). These authors found a decrease in almost all the technical actions along the 4 bouts. Probably, disparities in interpreting the technical actions and the different rules used may be reasons for the reported differences. Indeed, we arbitrarily decided to consider changes in direction turns larger than 90°. Furthermore, 2 touches make turns and dribbling more difficult compared with free touches. Additionally, the paper by Kelly and Drust (18) considered the total frequency of technical actions. However, to compare the technical scores between SSG of different durations, we normalized the data as number of actions per minute. In this study, we used 3 bouts. Given that passing accuracy decreased in the third bout, it is possible that the technical proficiency decreases by increasing the number of bouts, but this should be verified in future studies.

PRACTICAL APPLICATIONS

In conclusion, this study demonstrates that exercise intensity in 3-a-side SSG is influenced by duration with a reduction in HR for the SSG of 6-minute duration. No effect of duration was found for technical actions suggesting that the different durations (from 2 to 6 minutes) can be used interchangeably in terms of technical proficiency. Although we found significant differences in HR, the magnitude of changes were small, and therefore, the influence on the training-induced adaptations may be limited. Therefore, although this HR difference can have importance in research setting, the coach can use bout durations ranging from 2 to 6 minutes without affecting the quality and quantity of technical actions and ensuring an adequate physical training stimulus. Nevertheless, because there was a decrease in HR between 4 and 6-minute SSG and an increase in RPE, we suggest that 4-minute bouts can provide the optimal compromise-internal load for physical training (9).

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