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ORIGINAL ARTICLE

Heart rate responses and distance coverage during 1 vs. 1 duel in soccer: Effects of neutral player and different task conditions

Fréquence cardiaque et distance couverte lors du duel 1 vs 1 en football : effets du joueur neutre et des différentes consignes de jeu

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KEYWORDS
Football;
Extreme small-sided games;
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Goal;
Performance analysis

Summary
Objectives. — The aim of this study was to determine the effects of using neutral players and different task conditions in 1 vs. 1 small-sided games (SSG) on amateur soccer players' heart rate responses and distance coverage.
Equipment and methods. — Ten amateurs' soccer players (26.4 ± 5.3 years old, 8.0 ± 3.2 years of practice) from a Portuguese regional league participated in this within-subject repeated measures study. The heart rate responses, distance coverage, speed and acceleration were recorded by using heart rate monitors with GPS throughout all SSG.
Results. — Two-way MANOVA results revealed that neutral players ($F = 43.6$; $P = 0.001$; $\eta_p^2 = 0.017$; *Power* = 1.00; small effect size) and task conditions ($F = 84.7$; $P = 0.001$; $\eta_p^2 = 0.038$; *Power* = 1.00; small effect size) had significant main effects and small practical effects on heart

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rate responses and distance coverage. It was concluded that, in very small-sided game, the use of neutral players increased the heart rate responses and distance coverage.

MOTS CLÉS
Football ;
Petits côtés des jeux extrêmes ;
Duel ;
Analyse de la performance

Résumé
Objectifs. — Le but de cette étude était de déterminer les effets de l'utilisation des joueurs neutres et des conditions de travail dans 1 vs 1 petits jeux face (SSG) sur les réponses de la fréquence cardiaque joueurs de football amateurs et la distance parcourue.
Matériel et méthodes. — Dix joueurs de football (anciens 26,4 ± 5,3 ans, 8,0 ± 3,2 années de pratique) d'une ligue régionale portugais ont participé à cette étude. L'évolution de la fréquence cardiaque, la distance parcourue, la vitesse et l'accélération ont été enregistrées dans toute la phase de jeu.
Résultats. — Les résultats de la MANOVA bidirectionnelles ont révélé que les joueurs neutres ($F = 43,6$; $p = 0,001$; $\eta_p^2 = 0,017$; *Power* = 1,00 ; *small effect size*) et les conditions de travail ($F = 84,7$; $p = 0,001$; $\eta_p^2 = 0,038$; *Power* = 1,00 ; *small effect size*) ont eu des effets principaux significatifs et des petits effets pratiques sur les réponses de la fréquence cardiaque et de la distance couverte. Il a été conclu que, dans les très petites faces jeu, l'utilisation de joueurs neutres augmente l'évolution de la fréquence cardiaque et la distance de couverture.

1. Introduction

The use of small-sided games (SSG) in soccer training has been well studied in the last decade [1]. Their multiple effects on players' performance are believed to be useful in optimizing training specific to soccer [2]. Nevertheless, the use of SSG can be very different from coach to coach. In fact, a great number of task constraints can be used to change the games and induce different effects on players' performance [3]. Task constraints such as field dimension, game format, specific rules and targets, strategic/tactical missions, and coaches' encouragement have been studied and their effects on players' response have been reported [4—6].

In general, higher heart rate responses and time-motion characteristics of soccer players were observed in larger field dimension [4,7]. Likewise, some studies found that larger field dimension increases the number of individual technical actions [8]. About the formats of the games, it is consensual that smaller formats (i.e., less number of players) increase the heart rate responses, blood lactate concentration [9,10], and individual technical actions [7,11]. In addition, it has been found that SSG without goals and with coaches' encouragement increased the intensity of SSG [12,13]. However, these aforementioned studies only examined the different task conditions in common formats, which means that analysis on very small-sided game such as 1 vs. 1 duel is lacking. Moreover, the use of task conditions that improves the players' perception for a given tactical content is not studied with regularity. Thus, SSG are commonly investigated but small-sided and conditioned games (SSCG) that have a stronger tactical awareness seem to be not investigated. In that sense, the investigations do not follow the recent reality of training tasks based on tactical thinking [3].

Besides the aforementioned factors, one of the main manipulations used by coaches is the neutral player that provides to one team a temporary numerical advantage. It is usually use to develop a particular tactical content. For example, neutral player acts in the attacking process, thus helping the team with possession of the ball. Nevertheless, the reverse setting can be used to give support to defensive team. Among all previous studies in SSG, only two studies investigated this factor [14,15]. Both studies examined the performance variance between the games with and without neutral players. It was found that the use of attacking neutral players increased the heart rate responses in 2 vs. 2 format and the defensive neutral players increased the heart rate responses in 3 vs. 3 format. Despite the possibility to generalize those effects for 1 vs. 1, the results from these two studies cannot be assumed by the specific conditions of extreme format, moreover distance coverage was not measured. Moreover, the effects of neutral players in extreme SSCG are not too investigated. Theoretically, the use of neutral players in smaller formats may reflect greater effects than in bigger formats. Such hypothesis it is associated with the small number of options (team-members) in smaller formats, increasing the usefulness of playing with neutral members.

Another factor that is usually use by coaches in SSG is to change the way the goal is defined. Previous studies only compared the effects of using goals with goalkeepers against goals without goalkeepers, and it was found that SSG without goalkeepers increased the intensity of exercise [16—18]. Nevertheless, the effects of using reduced goal or other types of targets such as the endline have not been fully studied. Such conditions lead with physiological changes in players. Actually, the use of targets or goals (even in small-goals) increases the defensive organization around the goal, thus reducing the effort and counter-attack movements [13]. In the occasions of endline, the target is too big to have a great organization in the opponents, thus increasing the counter-attack and the effort. Such changes are even

more important in smaller SSCG formats, mainly to anaerobic workload [2].

Despite of importance of those task conditions (neutral players and zone of finalization), the studies on SSCG are too small. Moreover, the usefulness of extreme SSCG (smaller formats) to develop the anaerobic workload must be better understood, mainly by their important mission to increase the individual participation in technical drills. For those reasons, the addition of both extreme SSCG and different task conditions seems to be very important for the practical knowledge of coaches and for future plans of SSCG researches.

Therefore, the aim of this study was to investigate the effects of neutral players (with and without) and the different goal targets (no goals; no goals but endline; and reduced goals) on the heart rate responses and distance coverage of amateurs' soccer players during 1 vs. 1 duel. It was hypothesized that the use of neutral players increases the heart rate responses and reduce the distance coverage. It was also hypothesized that the SSG without a goal induces higher heart rate responses and distance coverage.

2. Methods

2.1. Participants

Ten amateurs male soccer players (26.4 ± 5.3 years old, 8.0 ± 3.2 years of practice, 179.0 ± 5.4 cm body height, 71 ± 7.1 kg body weight, 66.2 ± 10.2 bpm resting heart rate, and 189.6 ± 3.7 bpm of maximal heart rate) from Portuguese league voluntarily participated in this study (central defender: $n = 2$; full-backs: $n = 2$, central midfielder: $n = 3$, external midfielder: $n = 2$, forward: $n = 1$). The study was reviewed and approved by Coimbra College of Education (ESEC.004.10.2013) review board (ethics committee) before the study began. All players signed the Free and Clarified Consent Form respecting the Helsinki Declaration. The participants did not have any kind of physical or psychological diseases. All players were familiarized with the experimental procedures and the requirements of the games before the study began. All SSG duels were performed in the same day of week (Thursday) and the same time within the day in order to avoid any potential effects of circadian variation on players. In addition, data collection was conducted on Thursdays in order to ensure the best recovery between the matches, i.e., there was no training session on Wednesdays to ensure 24 hours of recovery prior to data collection. All SSG duels were conducted without wet conditions, temperature ranged between 11 °C and 15 °C, ranging from 64% and 87% of humidity.

2.2. Experimental approach

This study was conducted in 2 consecutive weeks: 3 SSG with neutral player were performed in one session of the first week, and 3 SSG without neutral player were performed in another session in the second week. During the first session, players performed 1 vs. 1 SSG with neutral players (i.e., 1 vs. 1_N) with three different task conditions being randomized. The three task conditions were:

- T1, maximize the ball possession time and there was no goal;
- T2, players were asked to cross opponents' endline with the possession of the ball and there was no goal;
- T3, a small goal (2 m of width and 1 m of height) was placed on the team's end line and the aim was to score.

In the second week, they performed 1 vs. 1 SSG without neutral player (i.e., 1 vs. 1) with three different task conditions being randomized. All SSG were played in synthetic turf, which all players trained and played in such turf from the beginning of season. The management of players' positions per game was random. The HR response and distance coverage were recorded throughout all SSG for further analysis.

2.3. 1 vs. 1 and neutral player

All SSG were played at the synthetic turf with dimensions of 15 × 10 meters. There were two neutral players each assigned to assist one team during the SSG. Each player within the field had only one neutral player. Neutral players were not included in the calculation of playing area because their participation was outside the field. Therefore, the field area per player was 75 m^2/player in all SSG as suggested by Little [2] as medium dimension in 1 vs. 1. All SSG were lasted for 3 minutes. In all SSG, a large number of balls were placed on the sideline to minimize the interruption of the game. In the beginning of each session a 15 minutes warm-up was performed followed by 3 minutes of passive recovery. During this period, the players based on their needs managed the hydration (only water) before and during games. No nutritional supplements were consumed during and in the hour before the study.

2.4. Task conditions

Three task condition were used in this study:

- T1: the aim was to maximize the ball possession time and there was no goal (Fig. 1a);
- T2: players were asked to cross opponents' endline with the possession of the ball and there was no goal (Fig. 1b);
- T3: a small goal (2 m width and 1 m height) was placed on the team's endline and the aim was to score (Fig. 1c).

2.5. Heart rate and distance coverage

To assess the heart rate at rest the heart rate monitor was used during a protocol of at least 10 minutes in a supine position and 7 minutes in a standing position in a quiet, semidark room, ensuring at a temperature of 20 to 22 °C as adopted by previous study [19]. The three lowest heart rate values were averaged and then used for analysis.

The Yo-Yo intermittent recovery test (level 1) was used to estimate players' VO_2max. This test consists of 20-m runs repeated twice, which are back and forward between the starting, turning, and finishing lines, and progressively increased speed was controlled by audio beeps from a tape recorded [20]. The heart rate response was measured using

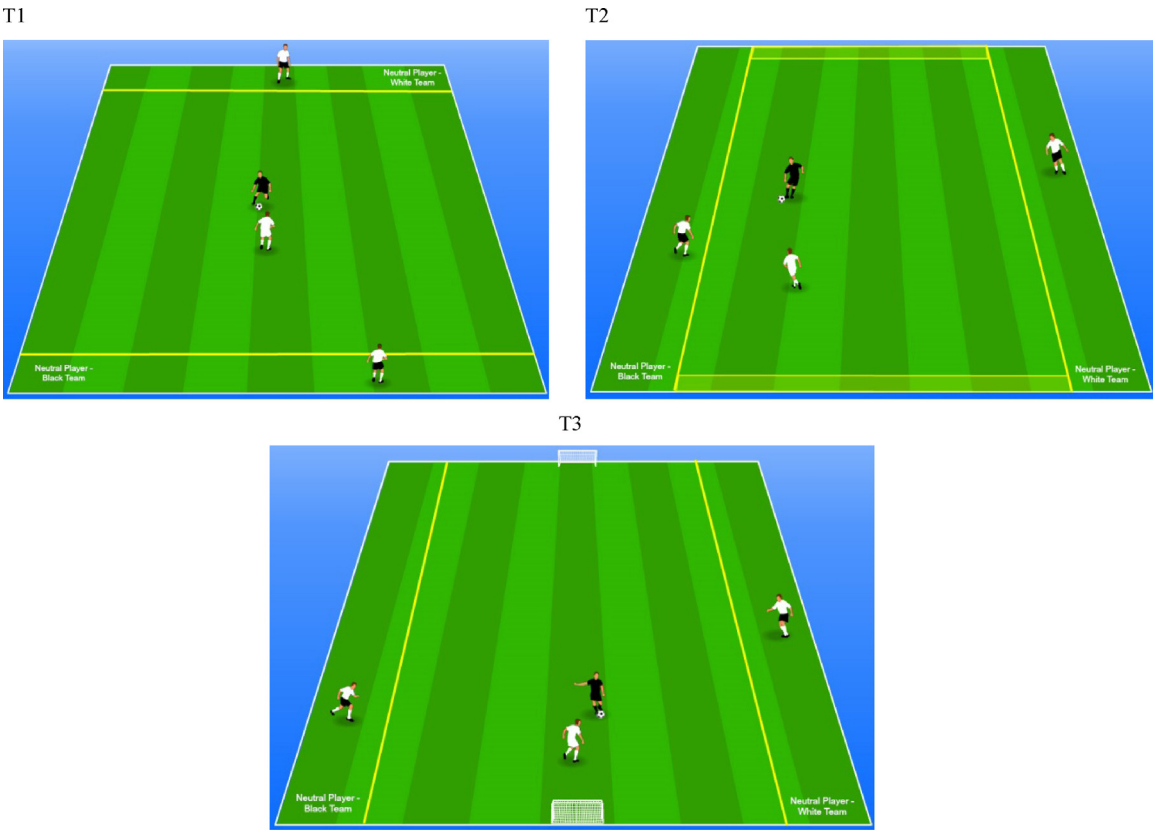

Figure 1 Three different task conditions used in this study: T1: maximize the ball possession time and there was no goal; T2: players were asked to cross opponents' endline with the possession of the ball and there was no goal; T3: a small goal (2 m width and 1 m height) was placed on the team's endline and the aim was to score. Player with white shirt and black shorts represents the neutral player.

the lightweight and portable hear rate monitor (Polar RC3 GPS with Heart Rate sensor, Finland) throughout the test at 1-second sampling interval. The maximum heart rate achieved by each player was determined by the average of the three highest values. Using the Bangsbo et al. [20] formula, the maximal aerobic capacity was estimated.

To assess the heart rate responses during SSG the heart rate monitors (Polar RC3 GPS with Heart Rate sensor, Finland) were placed in players' chest and recorded at 1-second interval. All heart rate data were then downloaded to a computer using the dedicated software (Polar WebSync and Polar Pro Trainer 5.0 software) and stored. The %HRreserve was computed using the Karvonen's method [21]. Using the same device (Polar RC3 GPS) the distance coverage (km) was also recorded at 1-second interval. Such device used the POLAR WIND technology, which is using 2.4 GHz transmission. The accuracy of the Polar RC3 GPS measurement is ±2% for distance and ±0.56 m/s for speed in moderate and low intensities.

2.6. Statistical analysis

Data are mean ± SD. The main and interaction effects of ''neutral player'' and ''task condition'' on the %HRres and distance coverage were examined by using two-way MANOVA after validation of normality and homogeneity assumptions. When MANOVA detected significant statistical differences between the two factors, two-way ANOVA for each dependent variable were then used. Tukey's HSD was used for post-hoc comparisons. All statistical analysis was performed using IBM SPSS Statistics (version 21), and statistical significance was set at $P < 0.05$.

The classification of the effect size was according to Hopkins et al. [22]: very small: 0—0.01; small: 0.01—0.09; moderate: 0.09—0.25; large: 0.25—0.49; very large: 0.49—0.81; and nearly perfect: 0.81—1.0.

3. Results

Two-way MANOVA results revealed that neutral player ($F = 43.6$; $P = 0.001$; $\eta_p^2 = 0.017$; *Power* = 1.00; small effect size) and task conditions ($F = 102.3$; $P = 0.001$; $\eta_p^2 = 0.038$; *Power* = 1.00; small effect size) had significant main effects on HR responses and distance coverage. Finally, significant interaction effects between the two factors on HR responses and distance coverage were observed ($F = 68.7$; $p = 0.001$; $\eta_p^2 = 0.026$; *Power* = 1.00; small effect size). Descriptive statistics were presented in Table 1.

3.1. Herat rate responses

As compared to 1 vs. 1, significant higher %HRres values were found in 1 vs. 1_N (80.1 ± 17.2% vs. 75.8 ± 15.7%;

Table 1 Descriptive statistics of the measured parameters.

	T1		T2		T3	
	%HRres	Distance coverage (km)	%HRres	Distance coverage (km)	%HRres	Distance coverage (km)
1 vs. 1	$70.2 \pm 20.4^{b,c*}$	$0.14 \pm 0.08^{b,c*}$	$77.3 \pm 13.8^{a,c*}$	$0.11 \pm 0.07^{a*}$	$80.0 \pm 8.9^{a,b*}$	$0.11 \pm 0.07^{a*}$
1 vs. 1_N	$78.7 \pm 19.3^{b,c*}$	$0.13 \pm 0.09^{b,c*}$	$83.9 \pm 14.3^{a,c*}$	$0.14 \pm 0.09^{a*}$	$77.4 \pm 17.3^{a,b*}$	$0.13 \pm 0.08^{a*}$

Significantly different compared to T1[a]; T2[b]; and T3[c] at $P < 0.05$. T1: no goal; T2: no goal but endline; T3: small goal.
* Significantly different compared to 1 vs. 1 and 1 vs. 1_N at $P < 0.05$

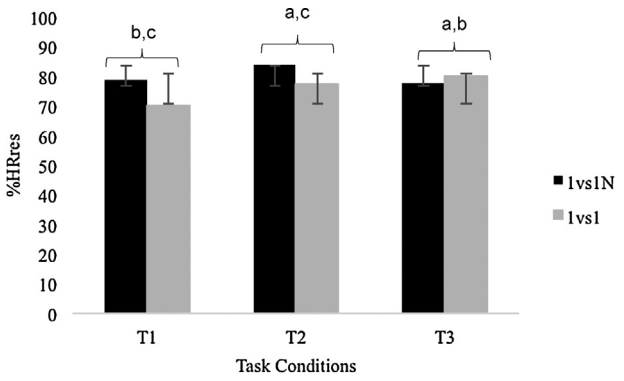

Figure 2 Comparison of heart rate responses between formats (with and without neutral players) and task conditions (T1: no goal; T2: no goal but endline; T3: goal). Significantly different compared to T1[a]; T2[b]; and T3[c] at $P < 0.05$.

$F = 82.1$; $P = 0.001$; $\eta_p^2 = 0.016$; *Power* = 1.00; small effect size). Fig. 2 illustrated the heart rate responses during the 6 SSG. In addition, there was also significant difference between the three task conditions in %HRres ($F = 62.0$; $P = 0.001$; $\eta_p^2 = 0.023$; *Power* = 1.00; small effect size). The T1 were significantly lower than T2 ($P = 0.001$) and T3 ($P = 0.001$). The T2 was significantly higher than T3 ($P = 0.002$).

3.2. Distance coverage

Univariate ANOVA results showed that significantly larger distance coverage (0.14 ± 0.08 vs. 0.12 ± 0.08 km; $F = 60.9$; $P = 0.001$; $\eta_p^2 = 0.012$; *Power* = 1.00; small effect size) were found during 1 vs. 1_N. Moreover, there was also significance difference of distance coverage between the three task conditions ($F = 16.1$; $P = 0.001$; $\eta_p^2 = 0.006$; *Power* = 1.00; very small effect size, Fig. 3). Post-hoc tests showed significantly higher values in T1 as compared with T2 ($P = 0.001$) and T3 ($P = 0.001$). The comparison between T2 and T3 did not show any significant difference ($P = 0.75$).

4. Discussion

The aim of this study was to examine the effects of neutral players and different task conditions on heart rate responses and distance coverage. The uniqueness of this study was that the extreme small format 1 vs. 1 duel was used. This study found that duel games with neutral players (1 vs. 1_N) significantly increased the heart rate responses and distance coverage. In addition, significantly higher values of heart rate responses were found in Task 2 (T2: no goal but endline). Significantly larger distance coverage was found in Task 1 (maximize the ball possession time and there was no goal) as compared to other two tasks.

In the present study, the use of neutral players significantly increased the heart rate responses and distance coverage in 1 vs. 1 duel. The HR values of 1 vs. 1_N (77.4 to 83.9%HRres) and duration of 3 minutes could be appropriate for anaerobic or lactate threshold training [2]. On the other hand, the intensity of 1 vs. 1 (70.2 to 80.0%HRres) could be more appropriate for aerobic training [21]. It is important to highlight that in the present study HRreserve rather than the HRmax was being used. The HRreserve produces somewhat higher values compared with heart rate computed as percentage of HRmax. Th Karvonen method uses about 50% of HRres as the lower-limit target threshold heart rate and 85% HRres as upper-limit target heart rate. On the other hand, intensity at 60%HRmax was the lower-limit for aerobic training intensity, and upper-limit about 90%HRmax for anaerobic training intensity [23].

Moreover, higher heart rate responses and larger distance coverage were found during 1 vs. 1_N as compare to 1 vs. 1. This could be explained by the opportunity to displace the ball from the opponent, stimulating the attack movements. Moreover, for the defensive player the numerical disadvantage may increase their distance coverage, trying to cover the player with ball and avoid the lines of passes for the other opponent player.

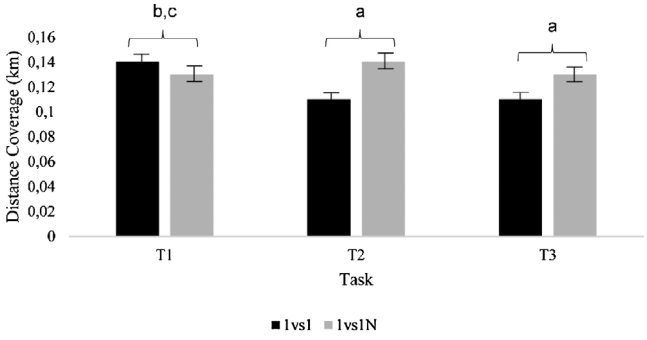

Figure 3 Comparison of distance coverage between formats (with and without neutral players) and task conditions (T1: no goal; T2: no goal but endline; T3: goal). Significantly different compared to T1[a]; T2[b]; and T3[c] at $P < 0.05$.

The use of neutral players is a typical task condition used by many coaches to promote specific tactical contents. The momentarily numerical advantage increases the opportunity of success against the opponent team. In the study of Bekris et al. [14], two formats (1 vs. 1 and 2 vs. 2) were used trying to understand the effects of using neutral players on heart rate responses and blood lactate concentration. In their study, both formats without neutral player were tested, with an attacking neutral player and with a defensive neutral player. They did not observed significant results despite higher heart rate values were found in the formats without neutral player. Nevertheless, using the 3 vs. 3 and 4 vs. 4 formats, Evangelos et al. [15] found that the use of neutral players increased the heart rate responses in 3 vs. 3 but it did not achieved statistical significance.

Moreover, in the present study, higher heart rate values were found in T2 as compared to the other two conditions. Such result could be partially explained by previous literature showing the use of central goals to increase the defensive organization and thus reduced the opportunity to penetrate into the defensive zone [18]. Such tactical behavior decreases the intensity of game by reducing the number of counter-attacks and space to explore [13]. Therefore, in the case of very small-sided games with an endline the space to score is larger, thus there is an opportunity to exploit the width thus increasing the distance coverage.

This study had some limitations. The technical level of amateur players it were not measured. In the future some instruments of technical and tactical efficacy must be add to control the players level and to clarify the results. Moreover, the accelerations and trajectories of players must be tracked in order to identify some patterns of playing in different formats and task conditions. Finally, will be necessary to execute this study in top players in order to test their fitness and the response to high intensity efforts such as extreme SSCG.

In this study, we also found that T1 induced lower heart rate as compared to the other two conditions. The aim of this condition was to maximize the ball possession time without a specific target. Such constraint reduces the orientation for a specific zone and the players may decrease the space to attack and only concentrate the player who possesses the ball. The mean heart rate for T1 was 75%HRres and this intensity could be appropriate for aerobic workout training. In the case of task 2 (81%HRres) and task 3 (78%HRres), the values are closer to an anaerobic training or even an intensive workout training [21] depending on the fitness levels of players.

Practical applications: this study showed that the use of neutral players increased the heart rate responses and distance coverage in extreme small-sided games (i.e., 1 vs. 1) among amateur soccer players. Moreover, we also found that the task conditions without a goal but with endline induced higher heart rate responses. These results may increase the knowledge about the effects of different task constraints on players' performance. Using the results of this study, coaches may be able to predict some players' responses in the specific training context.

It was found that the intensity of 80%HRres in 1 vs. 1_N and 76%HRres in 1 vs. 1 format. It is suggested that the 1 vs. 1_N can be more appropriate for the development of anaerobic system or threshold training depending on the fitness levels of players whereas the 1 vs. 1 for aerobic workout among amateurs soccer players. Nevertheless, the duration of workout must be carefully managed in order to ensure higher intensity when the target is to stimulate the anaerobic system. Periods between 30″ to 1′30″ can be used in this case. For aerobic training, it is recommended for the exercise to last for 1′30″ to 3′ at the intensity provided in the present study.

Disclosure of interest

The authors declare that they have no competing interest.

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