

EFFECTS OF SPECIFIC ENDURANCE ON THE PHYSICAL RESPONSES OF YOUNG ATHLETES DURING SOCCER SMALL-SIDED GAMES

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Abstract:

This study aimed to compare the physical responses of soccer players with different levels of specific endurance during SSG performed by teams balanced according to athletes' specific endurance. Eighteen U-17 athletes from a team that participated in national competitions took part in this study. The Yo-Yo Intermittent Recovery Test Level 2 (YIRT2) was used to measure the athletes' specific endurance. Then, athletes were allocated to two groups balanced according to their positional status and YIRT2 scores: in Group 1 players with the highest results in the YIRT2 and in Group 2 with the lower YIRT2 scores. Athletes played two four-minute bouts of 3 vs. 3 small-sided games with goalkeepers with four minutes of passive rest. Total distance covered, average speed, and accelerations were obtained by GPS devices carried by each player. Group 1 presented higher total distance covered (large effect size), higher average speed (large effect size), and higher total distance covered in accelerations above $1 \text{ m}\cdot\text{s}^{-2}$ (moderate effect size), compared to Group 2. We concluded that specific endurance can partially influence physical responses of young soccer athletes during small-sided games. This information is important to appropriately prescribe small-sided games during the training process, possibly by grouping together athletes with similar specific endurance and, therefore, promoting an adequate stimulus to better-conditioned athletes.

Key words: *Yo-Yo Test, motor profile, Global Positioning System, acceleration demand*

Introduction

Soccer performance is characterized by the dynamic interdependence of technical, tactical, and physical aspects (Aguiar, Botelho, Alves, & Sampaio, 2013) and the simultaneous development of these aspects represents a complex challenge for coaches and physical trainers (Morgans, Orme, Anderson, & Drust, 2014). The small-sided games (SSG) are a means of training that allows the development of athletes' physical condition (Hill-Haas, Rowsell, Dawson, & Coutts, 2009) in a tactical-technical context, which has led to a growing interest about the SSG prescription (Halouani, Chtourou, Gabbett, Chaouachi, & Chamari, 2014; Hoff, Wisløff, Engen, Kemi, & Helgerud, 2002; Sarmiento, et al., 2018). In this context, several studies have investigated the effect of altering different SSG characteristics, such as rules, number of players per team, and pitch size, on players' physical, physiological, and technical-tactical responses (Hammami, Gabbett, Slimani, & Bouhlel, 2018; Sarmiento, et al., 2018).

In regard to physical conditioning, the use of SSG training has shown to be as effective for developing aerobic performance as traditional running interval training (Hill-Haas, et al., 2009; Impellizzeri, et al., 2006; Moran, et al., 2019). During the formal game (11 vs. 11), it is known that athletes with higher aerobic performance (i.e., higher Yo-Yo Endurance Test scores) cover longer distances, present a higher number of sprints, and a higher number of ball touches compared to the athletes with lower aerobic performance (Redkva, Paes, Fernandez, & Da-Silva, 2018). Another study has showed that higher intermittent aerobic performance (i.e., Yo-Yo Intermittent Recovery Test level 1) is significantly correlated with the total distance covered and the number of high-intensity activities during a match (Castagna, Impellizzeri, Cecchini, & Alvarez, 2009). These data suggest that players' characteristics influence their responses during the formal game. Considering the structural differences between the formal game and the SSG, it is important to know whether players' charac-

teristics could impact players' responses during SSG. For example, a previous study showed that the level of tactical knowledge influences players' physical responses in SSG (Praça, et al., 2018), which reinforces the importance of the knowledge about players' individual characteristics in order to allow the prescription of the SSG during the training process in a more individualized manner.

Hoff et al. (2002) showed one example of such an influence. They reported that athletes with higher VO_{2MAX} presented a lower percentage of VO_{2MAX} during SSG (4 vs. 4 with goalkeepers, relative area of 250 m² per player, two 4-minute bouts with a 3-minute rest interval) compared to less conditioned athletes. The authors justified these results suggesting that a "ceiling effect" may have occurred and that the SSG may not provide a sufficient physiological stimulus to athletes with high aerobic performance (Hoff, et al., 2002). These results may be related to an increased ability to recover between high-intensity actions, leading to a lower physiological response. As an alternative aiming to overcome this possible limitation of SSG training and prescribe a more individualized training load, athletes with similar aerobic performances could be grouped to play SSG together. Köklü et al. (2012) reported that balancing teams according to players' aerobic performance increased mean exercise intensity during a soccer SSG. The results indicated that when teams with similar aerobic performance played against each other they covered higher distances and spent more time in higher heart rate (HR) zones compared to the other teams' composition criteria (i.e., technical performance and coach's subjective evaluation). Although these data suggest that coaches and physical trainers could divide players into teams balanced according to their aerobic performance to increase physical and physiological responses – which could lead to a more adequate stimulus especially for better conditioned athletes – it is unknown whether these groups could still present differences in these responses. The knowledge about different individuals' responses to SSG can help coaches to better prescribe and regulate training loads when using SSG.

Considering the abovementioned issues, this study aimed to compare the physical responses presented by soccer athletes of different levels of soccer specific endurance during SSG performed by teams balanced according to that criterium. We hypothesized that the athletes with a higher level of specific endurance would present higher physical responses (e.g., total distance covered, distance covered in different speed zones, accelerations) during SSGs compared to the athletes with a lower level of specific endurance.

Methods

Participants

Eighteen U-17 male soccer athletes from one professional soccer club participated in the study (16.2±0.9 years, 62.9±7.55 kg, 172.4±6.76 cm). They competed at a national level (Brazil) and had an average of seven training sessions per week. Before the start of the study, this research was approved by the local ethics committee and athletes and their legal guardians signed an informed consent form containing information about all the research procedures, risks, and benefits of taking part in the study. Participants could withdraw their consent at any time. Data from the athletes who presented any illness or injuries that prevented them to participate in all research sessions were excluded.

Procedures

During the research, athletes participated in one test session and three experimental sessions with a 7-day interval in-between. To avoid the influence of playing positions on the physical responses, athletes were first divided by their coach according to their playing positions (i.e., six defenders, six midfielders, and six forwards). In the test session, all athletes performed the Yo-Yo Intermittent Recovery Test Level 2 – YIRT2 (Krustrup, et al., 2006), which was part of the club's routine test battery. Although Krustrup et al. (2006) showed that the maximum oxygen consumption (VO_{2MAX}) estimated by the distance covered in the YIRT2 was significantly correlated to VO_{2MAX} measured in a treadmill test ($r = 0.56$; $p < .05$), this moderate correlation suggested a significant contribution of the anaerobic energy systems instead of a pure aerobic exercise. Therefore, the YIRT2 can be considered appropriate for athletes of intermittent sports, e.g. soccer, characterized by several high-intensity actions with short recovery intervals in-between (Krustrup, et al., 2003). The test also presents a coefficient of variation of 9.6%, indicating a moderate reliability of the test results.

The YIRT2 is an intermittent progressive test during which participants perform several shuttle-runs on a 20-meter path. There is a 10-second rest interval between each 40-meter run, when athletes must walk or jog. During the test, speed of running is controlled by beeps, initiating at 10 km·h⁻¹ and being progressively increased. Athletes finished the test when they were no longer able to maintain speed for two consecutive 20-meter runs.

Then athletes of each playing position were ranked (1st to 6th) according to their performance in the YIRT2. The three athletes of each playing position with the highest performance in the

YIRT2 were allocated to Group 1, so that Group 1 comprised nine athletes (three defenders, three midfielders, and three forwards) with the highest performance in the YIRT2. On the other hand, three athletes of each playing position with the lowest performance in the YIRT2 were allocated to Group 2, so that Group 2 comprised nine athletes (three defenders, three midfielders, and three forwards) with the lowest performance in the YIRT2. Each group was divided into three teams (A, B, and C) and in each team was one player of each playing position, as shown in Figure 1.

In the following three weeks, there were three experimental sessions on the same day of the week and at the same time of a day, to standardize possible circadian effects (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005). All data collection was carried out at the beginning of athletes' "regular" training sessions, after a 10-minute standardized warm-up (running, shuffling, short sprinting, and

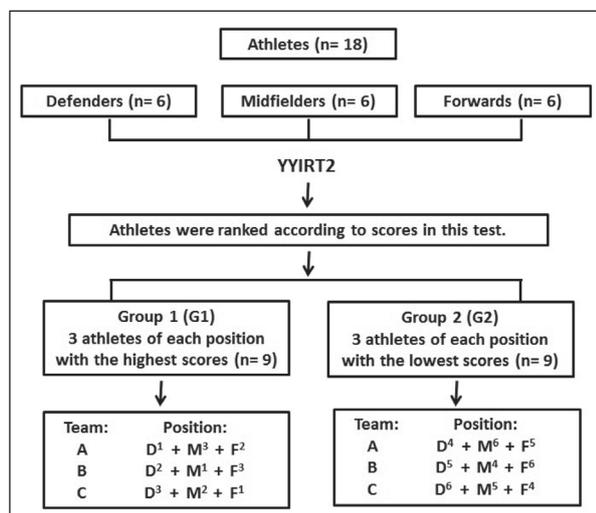
stretching). In each session, teams within each group (A, B, and C) played 3 vs. 3 SSG with goalkeepers against each other. The SSGs were carried out on a 36 x 27m pitch with two 6 x 2m goals, as previously reported in literature (Castelão, Garganta, Santos, & Teoldo, 2014). The offside rule was included, and throw-ins were taken with the foot, to enhance game dynamics. In each experimental session (1, 2, and 3) two teams from Group 1 (e.g., A and B) performed one SSG against each other and two teams from Group 2 performed one SSG against each other. Each SSG was played as two 4-minute bouts with a 4-minute rest interval in-between (Bredt, et al., 2016). Figure 2 presents the procedures performed in each experimental session.

Instruments and variables

Athletes physical responses during SSGs were measured using a global positioning system (GPS; Spi Pro X, GPSports) with a 5Hz sampling rate, interpolated to 15Hz for the acquisition of positional data. A triaxial accelerometer with a 100Hz sampling rate was also embedded in the equipment. During the SSG, athletes used a vest specially designed by the manufacturer to carry the GPS units, located in the upper part of the thoracic spine. In order to limit possible effects of between-units variability (Buchheit, et al., 2014), each athlete used the same unit during all the experimental sessions. Validity and reliability of this equipment were tested in a previous study (Köklü, Arslan, Alemdaroğlu, & Duffield, 2015).

The variables related to physical responses were: average speed, the distances covered while in different speed zones ($0-7.2 \text{ km}\cdot\text{h}^{-1}$; $7.3-14.3 \text{ km}\cdot\text{h}^{-1}$; $14.4-21.5 \text{ km}\cdot\text{h}^{-1}$; $21.6-25.5 \text{ km}\cdot\text{h}^{-1}$), the distance covered by accelerations higher than $1 \text{ m}\cdot\text{s}^{-2}$, and the distance covered while in different acceleration zones ($1-2 \text{ m}\cdot\text{s}^{-2}$; $>2-3 \text{ m}\cdot\text{s}^{-2}$; $>3 \text{ m}\cdot\text{s}^{-2}$). The distances covered by each athlete while in different speed zones were reported as both absolute distances (meters) and distances relativized by the total distance covered (%TD).

The speed and acceleration zones presented in this study were similar as in previous studies with



Note. G1 and G2 = athletes with higher and lower performance in the YYIRT2, respectively; YYIRT2 = Yo-Yo Intermittent Recovery Test Level 2; D = defender; M = midfielder; F = forward. Superscript number indicates the classification in the YYIRT2 performance ranking in each positional category from place 1 to 6.

Figure 1. Athletes classification into Group 1 and Group 2 according to playing positions and their performance in the YYIRT2.

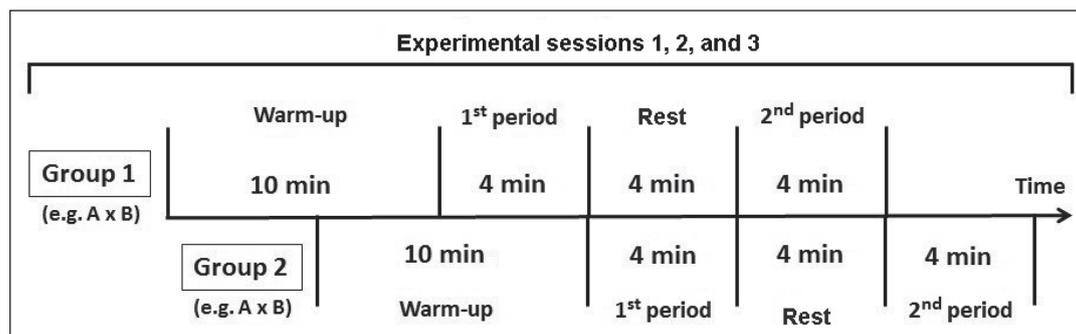
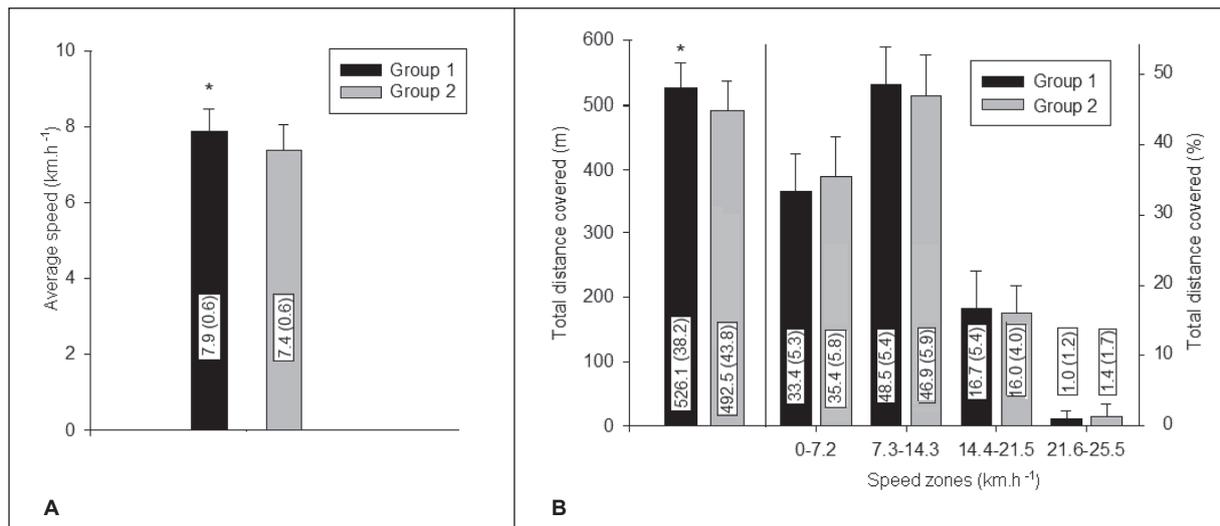


Figure 2. Procedures performed in each experimental session.



Note. * = $p < .05$

Figure 3. Means (standard deviations) of average speeds (A) and distance covered (meters, m, and percentage, %) (B) in speed zones per groups. Group 1 – group with higher performance in the YIRT2; Group 2 – group with lower performance in the YIRT2.

young soccer athletes (Brandes & Elvers, 2017; Bredt, et al. 2016) and soccer SSG (Hodgson, Akenhead, & Thomas, 2014). These zones may help to improve the understanding of athletes' physical responses and exercise intensity during the SSG (Malone, Lovell, Varley, & Coutts, 2017).

Data analyses

Data was first tested for normality (Shapiro-Wilk's test) and homoscedasticity (Levene's test). When parametric assumptions were met, independent *t*-tests were used to compare players' physical responses between Groups 1 and 2. Only the variable "percentage of total distance covered at 14.4-21.4 km·h⁻¹" did not present normal distribution. For this variable, the Mann-Whitney U test was used to compare Groups 1 and 2. It is important to highlight that both groups performed the same stimulus' duration. Therefore, the average speed and the total distance covered represent the same information.

The Cohen's *d* effect size was also calculated and classified as small ($d < .2$), medium ($d = .5$), or large ($d = .8$) (Cohen, 1988). The statistical analyses were carried out using SPSS 23.0 (Chicago, Illinois, USA). In all cases, statistical significance was set at 5%.

Results

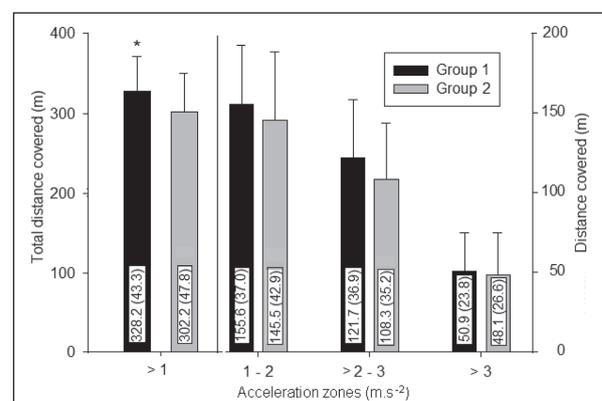
Table 1 shows the YIRT2 mean performance of each group. The independent *t*-tests showed that groups were significantly different in the total distance covered in the test.

Table 1. Mean performance in the YIRT2 of groups 1 and 2

Variable	Group 1	Group 2	p-value	ES
YIRT2 (m)	848.9 ± 97.5	675.6 ± 104.8	0.0022	0.650

Note. YIRT2 – Yo-Yo Intermittent Recovery Test Level 2; ES – effect size; Group 1 – group with higher performance in the YIRT2; Group 2 – group with lower performance in the YIRT2.

The comparisons of the physical responses presented by athletes with different specific soccer endurance levels showed that Group 1 presented a significantly higher average speed ($p = .001$; $d = .805$; large effect size), higher total distance covered ($p = .001$; $d = .815$; large effect size) (Figures 3A and 3B), and distance covered by accelerations above 1 m·s⁻² ($p = .018$; $d = .569$; moderate effect size) (Figure 4) compared to Group 2. The other variables were not significantly different between the groups.



Note. * = $p < .05$.

Figure 4. Means (standard deviations) of total distance and distance covered in particular acceleration zones per groups.

Discussion and conclusions

This study aimed to compare the physical responses of young soccer athletes with higher and lower levels of specific endurance during SSG played by teams balanced according to soccer specific endurance. We hypothesized that the athletes with higher specific endurance (Group 1) would present higher physical responses compared to the athletes with lower specific endurance (Group 2). The results partially confirmed our hypothesis, since Group 1 presented higher values only for three out of nine variables investigated: total distance covered, average speed, and distance covered by accelerations above $1 \text{ m}\cdot\text{s}^{-2}$.

The significantly higher average speed and total distance covered in the group with higher specific endurance reinforces the importance of this physiological aspect to determine physical performance in soccer athletes (Helgerud, Engen, Wisløff, & Hoff, 2001; Redkva, et al., 2018). This is the first study to show the influence of soccer specific endurance on players' physical responses during soccer SSGs. However, these data are similar to those related to the formal game, which showed that athletes with higher aerobic performance in the YIRT level 1 performed 28% more high-intensity running ($>18 \text{ km}\cdot\text{h}^{-1}$) and 58% more sprinting ($>30 \text{ km}\cdot\text{h}^{-1}$) (Mohr, Krustup, & Bangsbo, 2003). Helgerud et al. (2001) also showed a 20% increase in the total distance covered (1800 m) in the formal game after a post-training 10.8% increase in the $\text{VO}_{2\text{MAX}}$ in young soccer athletes. Considering that the SSG duration was the same in both groups, the increased average speed presented by the group with higher specific endurance corroborates the data related to the total distance found by Helgerud et al. (2001). Moreover, considering that in both the SSG and the formal game athletes perform intermittent high-intensity actions (Beenham, et al., 2017; Carling, Bradley, McCall, & Dupont, 2016), the higher physical responses found in the SSG for athletes with higher specific endurance reproduces the patterns found in the formal game (11 vs. 11).

In addition, we found that athletes with higher specific endurance (Group 1) also presented a higher distance covered by accelerations above $1 \text{ m}\cdot\text{s}^{-2}$. This result may be related to a higher number of high-acceleration actions, such as jumps, fakes, and sprints, which are crucial in the decisive moments of the game. It seems that higher specific endurance may influence players' ability to maintain acceleration demands during the SSG, possibly because of increased speed endurance and an improved recovery between these high-intensity movements (Aziz, Chia, & Teh, 2000). It is important to highlight that this result was found in a SSG duration as short as 4-minute, indicating that specific endurance might determine athletes' physical responses since the beginning of the game.

In regard to the other variables, although Group 1 presented higher distances covered while in the acceleration zones $1\text{-}2 \text{ m}\cdot\text{s}^{-2}$ (6.5%) and $>2\text{-}3 \text{ m}\cdot\text{s}^{-2}$ (10.8%) and speed zones ($7.3\text{-}14.3 \text{ km}\cdot\text{h}^{-1}$ – 0.09%; $14.4\text{-}21.5 \text{ km}\cdot\text{h}^{-1}$ – 0.11%), these differences were not significant. This result may be related to the division of the sampling data into zones, which decreased the amount of data within each zone and possibly increased variability of each variable. This might have hindered the finding of statistically significant differences between the groups. It is also likely that a higher number of bouts could have led to a higher distance covered within each speed/acceleration zone, especially in high intensity, as suggested by Mohr, Krustup and Bangsbo (2003). These authors found higher distances covered at high intensities ($>18 \text{ km}\cdot\text{h}^{-1}$) during SSG played as four 4-minute bouts with 3-minute rest intervals. The lower number of bouts analyzed in this study (2 vs. 4) may have not been sufficient to demand enough distance covered in each zone and, consequently, decreased the chances to find statistical significance between the groups.

Improvements in specific endurance allow players to recover faster between high-intensity stimuli (Aziz, et al., 2000). This influence of specific endurance on recovery may be better understood by the analysis of physiological parameters, such as heart rate and lactate threshold, not measured in the current study. Therefore, future studies should investigate other dependent variables to provide deep understanding of the influence of specific endurance on players' performance during soccer SSGs. Furthermore, the groups analyzed in this study presented only a moderate – although significant – difference for specific endurance, which still led to differences in physical performance during the SSG. Future studies should investigate a broader range of specific endurance levels, which will probably lead to differences in the other physical variables. Moreover, the influence of specific endurance on players' performance should also be investigated at different competition levels, since the level of experience and tactical knowledge can influence players' behavior during SSG and the responses achieved.

We conclude that young soccer athletes with higher specific endurance present higher speeds and total distance covered, as well as higher distance covered by accelerations above $1 \text{ m}\cdot\text{s}^{-2}$ than less conditioned athletes during 3 vs. 3 soccer SSG. This information is important to coaches and physical trainers to appropriately prescribe SSG during the training process, possibly by grouping together athletes with similar specific endurance and, therefore, promoting a more adequate stimulus to better conditioned athletes.

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