Comparative effects of game profile-based training (GPBT) and small-sided games on physical performance of elite young soccer players

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ABSTRACT

The present study was designed to investigate and compare the effects of game profile-based (GPBT) and small-sided games (SSGs) training on physical performances of elite youth soccer players during the in-season period. Twenty young soccer players (18.6 ± 0.6) were randomly assigned to either GPBT or SSGs protocols performed twice a week for 8 weeks. The GPBT consisted of 2 sets of 6-10 min of intermittent soccer specific circuits. The SSGs training consisted of 3-5 sets of 5 vs. 5 SSGs played on a 42 x 30 m pitch. Before and after the training **program**, the following physical performance were assessed: repeated sprint ability (RSA), **change of direction (COD)**, linear sprinting on 10-m and 20-m, jumping (CMJ), and intermittent running (YYIRL1). Significant improvements were found in all the assessed variables following both training interventions ($p < 0.05$). The GPBT group improved more than the SSGs group in the 10-m and 20-m sprint tests by 2.4% (*g* = 0.4; *small effect*) and 4% (*g* = 0.9; *large effect*), respectively. Conversely, the SSGs group jumped 4% higher (*g* = 0.4; *small effect*) and resulted 6.7% quicker than the GPBT (*g* = 1.5; *large effect*) in completing the **COD** task. These results suggest both GPBT and SSGs to be effective for fitness development among elite young soccer players during the competitive season. More importantly, these two conditioning methodologies may be considered in terms of specificity for selectively improving or maintaining specific soccer fitness-related performances in the latter phase of the season.

Key Words: change of direction; explosiveness; peak performance; power; sprinting; team sport.

INTRODUCTION

Soccer is a physically demanding sport characterized by an intermittent-activity profile with metabolic contributions of both the aerobic and anaerobic systems (18, 21). During a match, soccer players cover distances of 10-13 km and perform approximately 1,350 activities (every 4–6 seconds) such as accelerations/decelerations, changes of direction, and jumps, all of which are interspersed with short recovery periods (2, 28). Besides the physical prerequisites, soccer performance is related to technical skills, such as shots, crosses, passing, as well as to tactical factors such as team ball possession, attacking strategies, and the spatial locations of players (*e.g.* team formation) (3). Therefore, soccer coaches seek to match training requirements to the competitive demands of match-play with appropriate physical, technical and tactical stimuli (6).

Common methodologies used to address these needs are either small-sided games (SSGs) training or soccer specific training circuits. The main advantage of SSGs is the opportunity to develop simultaneously technical-tactical and physical sport-specific capabilities (17). SSGs are played on smaller pitches than regular match games and involve modified rules (*e.g.* number of touches, with or without goalkeepers, small goals, fewer players) (6, 17). Previous studies have largely documented the physiological demands of SSGs by reporting this training routine as able to heavily involve both aerobic and anaerobic metabolism as confirmed by increases of heart rate (HR) responses, O_2 consumption, blood lactate, and rating of perceived exertion (RPE) (6, 17). On the other hand, SSGs are unlikely to match the same external load demands of official competitions (*e.g.* high-intensity running, sprint distance) due to the high variability of the playing formats adopted. In fact, organizational parameters such as the number of players per team, game rules, coach encouragement, all have an important impact on the players' internal and external loads (24). Another possible limitation is represented by the heterogeneity and the unpredictability of the individual physical responses to SSGs, which **may** be dictated by players' positions, technical skills, and fitness level (17).

Soccer specific training using field-based circuits may be a valid alternative to SSGs offering equivalent internal loads but concurrently replicating the external load demands of match-play. Hoff at al., (18) suggested that this training method may be even more effective for developing aerobic performance than SSGs. This assumption relies on the lower heterogeneity and inter-subject variability of the players' physiological responses compared to SSGs (24). In fact, this conditioning methodology is performed in the form of fixed paths and dictated soccer-related activities which ensure low intra- and inter-player variability of the imposed training loads and intensities (12, 18). A novel soccer training circuit was recently developed as a valid training method to develop long-term fitness adaptations in soccer (12). The GPBT proposed by Dello Iacono et al., (12) consisted of 3 bouts of 8 minutes of combined physical and technical activities (*e.g.* high-intensity intermittent running, changes of direction and passes), which replicated the type of movements and physical demands (e.g., internal and external loads) of match-play. The external load responses induced by the GPBT in elite youth soccer players were reported to be higher than those of UEFA Youth League matches especially in terms of high-speed distances and high-intensity efforts (12). Such high-intensity activities may have an important acute impact on neuromuscular function, as confirmed by the greater detrimental effects on jumps performance immediately after the GPBT (*moderate* to *large* effect) compared to the decrement found after UEFA Youth League matches (*small* effect) (12). Furthermore, the internal load responses induced by the GPBT were higher (*e.g.* RPE) or equivalent (*e.g.* HR and blood lactate) to those reported during the official matches. These findings support the assumption that GPBT may recreate the high metabolic and mechanical demands seen during official matches and competitions.

While the acute internal and external load demands of a GPBT have been previously reported (12), to the best of our knowledge there is no study that has evaluated the chronic physical adaptations following a period of GPBT training in a cohort of soccer players. Consequently, the aim of this study was to compare the chronic effect of eight weeks of GPBT vs. SSGs training in elite soccer players. Our first hypothesis was that either GPBT or SSGs training performed twice a week would enhance physical determinants of soccer specific performance. We also hypothesized lower variability of the associated training responses induced by the GPBT due to the controlled nature of this conditioning methodology.

METHODS

Experimental Approach to the Problem

This study adopted a repeated measures design with counterbalanced and randomized allocation to training intervention. Participants were divided into two training groups that performed either GPBT or SSGs **of equal weekly and total volume,** in addition to their normal soccer training sessions. The two training interventions reflected what soccer coaches and fitness trainers usually implemented during the competitive season. In methodological terms, this approach promoted ecological validity of the possible outcomes of this investigation. The study was conducted during the last part of the soccer in-season period (March to May). Overall, the study lasted ten weeks and consisted of one week of pre-testing, eight weeks of specific training (twice a week), and one week of post-testing. To isolate the effect of the two training protocols, the additional fitness training sessions (*e.g.* technical, tactical, and strength) during the eight weeks of training were identical for both groups. Physical performance tests included a countermovement jump (CMJ), 10-m and 20-m sprints, RSA test, and a Yo-Yo intermittent recovery level 1 (YYIRTL1).

Participants

Twenty male **outfield** soccer players took part in the study **(GPBT [*n* = 10], age: 18.5 ± 0.6 years, stature: 177.4 ± 1.1 cm, body mass: 73.1 ± 3.2 kg, maximal heart rate [HR_{max}]: 203 ± 1.0 beats min^{-1} and of body fat [%]: 9.2±1.1%; SSGs [*n*=10], age: 18.7±0.6 years, stature: 177.9 ± 1.3 cm, body mass: 73.5 ± 2.7 kg, HR_{max}: 201 ± 1.8 beats min^{-1} and body fat [%]: 9.2 ± 1.1%).** Players were members of a U-19 soccer team participating in the national youth league and the UEFA Youth League group stage. They had at least six years of experience in systematic training within a professional youth academy framework. Prior to the study's commencement and throughout the intervention period, both training and match play exposure for all the twenty players was kept similar. They trained once a day for ≈90 min, five days per week, and underwent technical, tactical, strength, and speed training. All the players and/or their parents/guardians gave their written informed consent after receiving a detailed explanation about the potential risks of the training. The study was conducted according to the Declaration of Helsinki, and the protocol was fully approved by the Institution's Ethics Committee.

Procedures

Testing Schedule

The testing schedule included three similar sets of tests performed two weeks before the initiation of the study, the week prior and the week after the eight weeks of training period, respectively. The first set was conducted with the aim of getting the participants familiarized with the testing procedures. In addition, tests results of set one and two were also used for assessing the test-retest reliability of the measures. All sets of tests were administered on three non-consecutive days using the same procedures by two researchers, who were blind to the training-group affiliation. On the first test day, following the anthropometric assessment, a

repeated sprint ability (RSA) test was performed. On the second day, CMJ and sprint performances were assessed. On the third day, the YYIRTL1 was performed. During the YYIRTL1, the HR_{max} values of each player were determined as the peak HR observed during the test, and they were further utilized for the calculation of the HR responses during both training interventions. All tests were performed on the same regular outdoor field, at the same time of the day (5:00 p.m. - 7:00 p.m.) and in similar ambient conditions of temperature (22.5 ± 2.5°C) and relative humidity (65 ± 3.8%). In order to prevent unnecessary fatigue effects, players and coaches were instructed to avoid intense training 24 h prior to each day of testing. Players were also asked to keep a regular diet during the testing weeks, to fast at least 2 hours before each testing session, and were prohibited from consuming any known stimulant (*e.g.* caffeine) or depressant (*e.g.* alcohol) 24 h before testing.

Day 1

Anthropometry

Anthropometric variables of height (cm), body mass (kg), and body fat (%) were measured three times for each participant and the mean of each measure set was calculated. Stature and body mass measurements were made on a leveled platform scale (SECA model 284, Germany) with an accuracy of 0.001 m and 0.05 kg, respectively. Percent body fat was calculated from measurements of 7 skinfold thickness according to the equations of Jackson and Pollock (22).

Repeated sprint ability (RSA)

The RSA test involved six repetitions of maximal 2 × 12.5-m shuttle sprints (~6 s) departing every 20s as previously described (11). During the recovery intervals between sprints, subjects were required to stand passively. Two seconds before starting each sprint, the participants were asked to assume the start position, with the front foot placed 5 cm before the first timing gate and await the start signal for the next sprint. Strong verbal encouragement was provided to each subject during all sprints. Time was recorded using photocell gates (Timing-Radio Controlled, TT-Sport, San Marino) placed at the start-finish point and on the 10-m lines, approximately 0.5 m above the ground, and with an accuracy of 0.001 s. Three scores were calculated for the RSA test: the best sprint time (RSA_{best}, s), the mean sprint time (RSA_{mean}, s) and the percent sprint decrement (%Decr, %), calculated as follows:

$$100 - (\text{mean time} / \text{best time} \times 100)$$

In addition, the **COD** performance was calculated as the time in completing the 2 × 2.5-m turn-around, between the 10-m and 15-m lines crossing, respectively.

Day 2

Countermovement jump (CMJ)

CMJ test was performed according to the protocol of Bosco et al (5). Participants were instructed to keep their hands on their hips to prevent the influence of arm movements. Starting position was stationary, erect, with knees fully extended. The subjects then squatted down to about ~90° of knee flexion before starting a powerful upward motion. They were instructed to jump as high as possible, and verbal encouragement was provided to each subject before each trial. Each athlete performed three trials with passive recovery of 45 s between jumps, and the best result was recorded. The height of each jump (cm) was assessed with the Optojump apparatus (Optojump, Microgate, Bolzano, Italy).

Sprint Tests

Sprint ability was evaluated by a 10-m and a 20-m standing-start all-out run. The subjects were asked to assume the start position, as already detailed for the RSA, and await the start signal. Strong verbal encouragement was provided to each subject during all sprints. For time measurement, the test was conducted using the same equipment as in the RSA test. The 10-m and 20-m sprint were performed three times, separated by at least two min of passive recovery between tests. The best performance was recorded and used for further analysis.

Day 3

YYIRTL1

The YYIRTL1 was used to assess players` aerobic capacity according to the protocol of Krustrup et al (26). Recorded paces of the YYIRTL1 test were broadcast using speakers placed on the sides of the field. The end of the test was determined when the player failed to arrive within 2m of the end line on two consecutive tones. The total distance (m) covered during the YYIRTL1 (including the last incomplete shuttle) was considered as the testing score. **The final speed corresponding to the last shuttle of the YYIRTL 1, namely maximal aerobic velocity (MAV), was also used to calculate the individual intermittent running distances covered during the GPBT protocol.**

Training protocols

GPBT Protocol

The GPBT protocol consisted of 2-3 sets by 6 to 10 min (Table 1) of intermittent bouts combining physical and technical activities, such as walking; low-, moderate-, and high-intensity intermittent (HIIR) running; sprinting with **COD**; and passing drills as described by

Dello Iacono et al (12). **Subjects moved alternately from the left to right side of the protocol setup or vice versa after each bout.** An example of the GPBT protocol pattern is presented in Figure 1. Exercise intensity was set at 50-75-105% (for low-, moderate-, and high-intensity running, respectively) **of the MAV reached during the YYIRTL1**. **The equivalent intensity intermittent running distances were marked on the field by using colored cones. Subjects ran through these distances while listening to an auditory pacer signal broadcasted using speakers placed on the sides of the field. Training intensities were monitored by ensuring the subjects could cover their individual running distances at the prescribed pace.** Dello Iacono and colleagues have previously shown that this protocol was able to induce an intensity that corresponds to ~120% of VO_2max (12). The GPBT protocol was designed considering a linear periodization model with the overload built across the first seven weeks by gradual increases in training volume, then followed by a tapering week when the training duration was reduced by 40%. **Each GPBT session was performed at the beginning of a training session after a 20-min warm-up which consisted of low-intensity running, mobilization, dynamic stretching and COD drills.**

*****Figure 1 about here*****

*****Table 1 about here*****

Small-sided games (SSGs)

The SSGs format was structured as 5 against 5 games, with goalkeepers, using regular goals, free touches, and with the ball always being replaced promptly when out of play. The size of the playing area was 42 x 30 (1260 m^2**)** with a relative playing area per of 126m^2 (32). Encouragement was provided by the coaching staff members. Over the course of the study, the SSGs were performed as interval training consisting of 3 to 5 bouts of 4 min duration with 2 min of passive recovery between bouts. As detailed in Table 1, the SSGs protocol followed the same periodization model of the GPBT thus ensuring that the two exercises' durations were matched up for each training session and kept equal across the intervention period (Table 1). In accordance with the **GPBT training protocol, the SSGs were also conducted at the beginning of a training session after the same warm-up routine.**

Load monitoring

External Load

The time-motion variables were collected with 20 GPS units working at a sampling frequency of 15 Hz (SPI-Pro X II, GPSports, Canberra, Australia). A special vest was tightly fitted to each player, which held the receiver between the scapulae. All devices were always activated 20-min before the data collection to allow for the acquisition of satellite signals (38). The minimum acceptable number of available satellite signals was 8 (range 8-11) (38). In addition, in order to avoid inter-unit error, each player wore the same GPS device for all training sessions (35). The literature investigating the validity and reliability of 15 Hz devices has recently reported acceptable ranges of variability for the measures of distances and speeds in common soccer-based movements (1, 25). The variables recorded in our study were: the relative distance covered per minute (RD; $m \cdot min^{-1}$), and the relative distance covered per minute (HSD; $m \cdot min^{-1}$) in a high-speed zone (> 19 $km \cdot h^{-1}$) (1, 30) . Sprint efforts were also collected and calculated according to the method detailed by Schimpchen et al (34). Specifically, the sprint distances were collected upon individualized thresholds rather than fixed and objectives ones. **We adopted the individualized thresholds calculation method that uses a percentage of peak running velocity (PV) reached during within-match sprinting. An absolute sprinting threshold was set at 25.2 $km \cdot h^{-1}$, and this velocity was taken as a reference point (34). Thus, to individualize sprinting thresholds as a percentage, the equation below was used:**

$$(25.2/\text{within-match PV}) \times 100$$

Another time-motion parameter was the amount of high-intensity efforts per minute (HIE; $n \cdot min^{-1}$). This variable was calculated by summing up the relative number of occurrences per minute of sprints, and the locomotor activities included, in one of the following two acceleration categories: high deceleration (HD; < -2 $m \cdot s^2$) and high acceleration (HA; > 2 $m \cdot s^2$) (30).

Internal Load

Heart rate responses

HR responses were monitored during the SSGs and GBPT to provide the mean heart rate percentage (%HR_{mean}), which is more indicative of what occurs over the entire training session compared to HR_{max}. HR responses were recorded using the POLAR Team[2] Pro system (Polar Electro Oy, Kempele, Finland) at 5 s intervals throughout, and then filtered using a software-embedded proprietary algorithm. The HR_{max} used for reference for the HR responses during both training protocols were those measured during the YYIRTL1 test.

Rating of perceived exertion (RPE)

Players indicated their rating of perceived exertion (RPE) using the category rating 10 (CR-10) scale modified by Foster et al. (16) at the end of the experimental session, using a standardized questionnaire. All players were familiarized with this method as it was employed by the coaching staff as a load monitoring tool.

Statistical Analysis

All data are presented as means ± standard deviation (SD) and confidence interval (95%CI). The Shapiro-Wilk test was used to ensure normal distribution of the results. Homogeneity of variance between the two groups was examined with Levene's test. The Intra-Class Correlation Coefficient (ICC) was used to determine the consistency of the measures between the two pre-training assessment points. Based on the 95% CI of the ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 were indicative of *poor*, *moderate*, *good*, and *excellent* agreements, respectively. For the intra-day reliability, the spreadsheet of Hopkins (19) was used to determine the typical error of measurement of the RSA, CMJ and sprint tests at both pre- and post-training points, expressed as Coefficient of Variation (CV%) with 95% CI. CV% values ≤ 5% were considered acceptable. The intra-subject (individual variability across the training sessions) and the inter-session (group variability across the training sessions) reliability of the training load responses for each group were also calculated and expressed as CVs. Independent samples t-tests were used to evaluate differences in the internal and external load responses **and the relative intra-subject and inter-session reliability scores** between the two groups. A repeated measures two way analysis of variance (ANOVA), with baseline measures as a covariate, was used to determine the main and interactive effects of training (20). The independent variables included 1 within-subjects factor (time), with 2 levels (baseline and post-intervention), and 1 between-subjects factor (protocol) with 2 levels (GPBT vs. SSGs). Bonferroni post hoc-tests were used if interactions were identified. 95 % CI of the mean difference and Hedges *g* effect sizes were calculated when comparing between groups (mean differences/pooled SD within the two groups). The magnitudes of these effect sizes were classified as *trivial* (0–0.19), *small* (0.20–0.49), *medium* (0.50–0.79) and *large* (0.80 and greater) using the scale proposed by Cohen (7). The level for statistical significance was set at $P < 0.05$. Statistical analysis was performed using Jamovi statistics software (Version 0.9.1.10).

RESULTS

Normality of data and the homogeneity of variance were confirmed. The 95% CI of ICCs between the test-retest measurements ranged from 0.834 to 0.942 for all the measures, indicating *good* to *excellent* agreement between trials (Table 2). At baseline and post-test intervention points, all the physical tests variables showed high intra-test-reliability, with CVs ranging from 1.63 to 3.33% (Table 2). The intra-subject and inter-session RD, HSD and SD responses resulted significantly less variable during the GPBT compared to the SSGs **(all $p < 0.05$)** (Table 3).

There were no significant baseline anthropometric or physical capability differences between the groups (all $p > 0.05$) at baseline. Significant differences across all the training sessions were observed between the groups in terms of external load responses with greater RD ($p < 0.05$), HSD ($p < 0.05$) and relative SD ($p < 0.05$) during the GPBT, and greater HIE ($p < 0.05$) during the SSGs (Table 3). No significant main effect for group were identified on HR_{max} ($p < 0.05$), $\%HR_{mean}$ ($p < 0.05$) and RPE ($p < 0.05$) (Table 3).

There was a significant improvement in the CMJ, 10-m sprint, 20-m sprint, **COD**, RSA_{best}, RSA_{mean}, %Decr and YYIRTL1 following both training interventions (all $p \leq 0.05$, *moderate* to *large* effects) (Table 4).

Time x group interactions were observed in relation to CMJ ($p < 0.001$), 10-m sprint ($p = 0.019$), 20-m sprint ($p < 0.001$) and **COD** ($p < 0.001$) as effect of training intervention (Table 4). Post-hoc comparisons revealed that, following the intervention period, players of the GPBT group were 2.4% (95% CI: 1.3%, 3.5%, $g = 0.4$) and 4% (95% CI: 2.5%, 5.4%, $g = 0.9$) faster than those of the SSGs group in the 10-m and 20-m sprint tests, respectively (Table 4). Conversely, at post-intervention testing, the SSGs group jumped 4% higher (95% CI: 2.2%, 6.2%, $g = 0.4$) and were 6.7% quicker than the GPBT (95% CI: 5.1%, 8.3%, $g = 1.5$) in completing the **COD** task included in the RSA test (Table 4).

No significant between-group differences were identified in relation to RSA_{best} ($p > 0.05$), RSA_{mean} ($p > 0.05$), %Decr ($p = 0.434$), and YYIRTL1 ($p > 0.05$) (Table 4).

*****Table 2 about here*****

*****Table 3 about here*****

*****Table 4 about here*****

DISCUSSION

The aim of this study was to compare the effects of GPBT vs. SSGs training on several physical capabilities of young elite soccer players during the in-season period. The results indicated both training regimens as being effective in improving the assessed physical performances after eight weeks. First**ly**, RSA and YYIRTL1 had similar improvements in both the GPBT and SSGs groups. Second**ly**, specific adaptations to each training regimen were found. Greater enhancements in linear sprint (*e.g.* 10-m and 20-m) abilities were observed after GPBT, whereas jumping (*e.g.* CMJ height) and **COD** performances improved more after SSGs training.

As expected, both training interventions led to better RSA-related scores highlighting the enhanced capability of the players to repeatedly complete maximal sprint efforts. The improved RSA_{best}, RSA_{mean} and %Decr scores suggest GPBT and SSGs training are equally capable to induce beneficial effects on maximal sprint performances and on the ability to recover quickly between repeated sprint bouts (31). The improved maximal sprint ability (*e.g.* lower RSA_{best}) (Table 4) may be the consequence of enhanced peripheral neuromuscular properties of the lower limbs' muscles during the sprinting tasks (27, 29). This assumption is further supported by the parallel improvements observed in CMJ and linear 10-m and 20-m sprint performances (Table 4). These findings confirm the known relationship between vertical jump and short duration sprint performances which are highly correlated between each other (11, 13, 23, 24). Therefore, the repeated high intensity efforts demanded in both training interventions (Table 3) may have represented the underpinning conditioning stimulus leading to positive adaptations and improved RSA performances. The enhanced recovery ability between the repeated sprint efforts, shown by lower %Decr and overall performances (*e.g.* lower RSA_{mean}) scores in both groups, can be explained by a possible parallel improvement of the aerobic energy system capabilities (4). In fact, the YYIRTL1 final score, representative of maximal aerobic fitness level, improved by 27% and 21% in the GPBT and SSGs group, respectively (Table 4). The physiological adaptations associated with higher aerobic fitness levels are known to facilitate the recovery process between repetitive sprinting bouts (36, 37). Our findings conform to previous research showing a high aerobic capacity to be correlated with improved RSA and, therefore, advocating the advantages of superior aerobic fitness levels for sustaining repeated maximal sprint efforts (4).

This study also revealed significant increases in the YYIRTL1 following both GPBT and SSGs training. The GPBT outcomes observed in our study are in line with the findings of Dello Iacono and colleagues (12) reporting greater external load and similar physiological responses for the GPBT protocol compared to official matches. The GPBT is characterized by repetitive bouts of running at low to high intensities performed intermittently and interspersed by short recovery periods. Indeed, the concurrent occurrence of high intensity efforts, as confirmed by the training sessions responses, **as well as** the cumulative time spent by training above optimal training thresholds (*e.g.* $HR_{mean} > 85\% HR_{max}$) as evident from **Table 3**, make the GPBT an efficient training stimulus for aerobic fitness components (9, 15, 18). Similarly, SSGs training was found to be an effective alternative to the GPBT for improving aerobic fitness conforming to the current literature (10, 17, 25). Despite the different locomotive patterns of the GPBT and SSGs training, the physiological responses monitored during the sessions were not significantly different between the two regimens. We found similar internal loads values expressed by the $\%HR_{mean}$, HR_{max} and RPE values (Table 3). On the other hand, significantly different external load responses were demonstrated in the two protocols. Greater RD and HSD were generated from the GPBT, whereas higher amounts of HIE were derived from the SSGs (Table 3). These findings clearly highlight the different nature of the two training methodologies which, in turn, may also underpin alternative conditioning mechanisms leading to improvements in aerobic fitness. Possessing an elevated aerobic capacity may lead to some adjunct benefits in youth soccer like greater involvement with the ball, total distance covered, increase in the number of sprints performed during match and team success. The GPBT could represent an efficient high-intensity interval training form for improving maximal oxygen uptake. On the contrary, the higher frequency of repeated HIE associated with the SSGs makes this a preferable training option for improving mechanical efficiency during accelerations, decelerations and changing of directions tasks which largely characterize the YYIRTL1. This assumption is further supported by the parallel greater improvements of the **COD** performances following the SSGs training compared to the GPBT (Table 4). Our findings are in line with Dellal et al. (10) who showed that 6 weeks of soccer SSGs training increase aerobic capacity and the ability to repeat high-intensity actions with directional changes of soccer players at a proportion similar to that of the high-intensity intermittent exercise training.

Interestingly, the results also suggest a possible advantage of using the GPBT over the SSGs due to the higher homogeneity in the players' performance improvement changes. As shown in Table 3, the intra-subject and inter-session CVs scores of the GPBT group were **significantly** lower than those of the SSGs group. Previous research has also found that inter-participant variability during soccer specific training circuits is lower than in SSGs (18, 24). Moreover, the range of the performance improvements at post-intervention point – as seen by the size of the mean changes' SD – was smaller in the GPBT group compared to SSGs group. These findings lead us to assume that GPBT should be preferably prescribed as a long-term conditioning method during the in-season period in an attempt to improve soccer players' aerobic fitness due to the higher homogeneity and less variability of the training responses and physical adaptations compared to SSGs.

The greater enhancement of the 10-m and 20-m sprint performances following the GPBT may be largely explained by the higher expsosure to maximal intensity actions and covered sprinting distances as part of the GPBT protocol. As can be seen in Figure 1, the GPBT group completed sprinting efforts during each running bout for a total of 12-20 per session (Table 1). Conversely, the uncontrolled responses of the SSGs due to the playing format and pitch size adopted, game rules, coach encouragement and team tactical behaviors (17) may have impacted the players' and limited their exposure to maximal sprint actions. The external load responses (Table 3) support this hypothesis. The HSD and SD covered during the GPBT were two-fold higher than those resulting from the SSGs training (10.2 m/min vs. 4.6 m/min and 4.3 m/min vs. 2 m/min, respectively). The higher intra-subject and intra-session variability of the HSD and SD associated to the SSGs training may have also greatly contributed to such effects. An additional possible explanation for the greater improvement on 10-m and 20-m after GPBT may be the evident presence of training exercise specificity between this training modality and the sprinting tests. From a mechanical perspective, the main characteristic of the GPBT was the predominant horizontal-oriented forces profile of the demanded in-line activities (Figure 1). As a consequence, performing the GPBT repeatedly may have represented an optimal conditioning stimulus and increased the chances for the GPBT group to make greater adaptations, considering the importance of horizontal force production and its application in linear sprinting performance (13, 14, 27, 29).

Another finding of this study was the significantly greater improvement in jumping and **COD** performances after SSGs training compared with GPBT (Table 4). From a conditioning perspective, the greater CMJ and **COD** improvements may be a consequence of the cumulative effects induced by the repetitive and more frequent HIE performed during the SSGs (+35%) in comparison to the GPBT (Table 3). When playing SSGs, these efforts could have occurred from the recurring "duels" and "one-on-one" situations forcing players to withstand and to overcome an opponent who was attempting either to score or to avoid goals (8). Salaj and Markovic (33) have previously reported that very short and high-intensity actions represent a conditioning stimulus for the bi-articulate muscles of the lower limbs which are known to be determinant for multi-joint movements like jumping and changing direction. Another likely explanation for the improved **COD** performance in the SSGs group may be the evident presence of training specificity between the locomotive patterns of this exercise and the COD task. **COD** is a complex ability depending on coordination, dynamic balance and flexibility besides muscle strength capabilities (33). To improve this task it appears necessary to stress the underlying athletic components of interest under similar conditions. Indeed, using SSG may provide a superior stimulus to promote functional adaptations in the **COD**-related fitness variables, as supported by our results.

In conclusion, both the training methods seem to be generally effective for soccer-related fitness maintenance and improvement in youth players during the last phase of the season. More importantly, these two conditioning methodologies may be considered in terms of specificity for selectively improving or maintaining specific soccer fitness-related performances. Specifically, GPBT training was more effective in conditioning linear sprint capabilities while SSGs induced more beneficial effects on jump and **COD**. Finally, our second hypothesis was also confirmed given the lower variability scores of the intra-subject and inter-session training responses during the GPBT compared to SSGs.

There were a number of limitations. Firstly, the collected measures are all surrogates of physical performance metrics for soccer. Future studies should also measure more soccer-specific tests, such as multidirectional **COD** tests and technical skills tests. **Secondly, the absence of a control group in which participants would have completed the regular training sessions and played the official matches without participating in any of the experimental protocols, delimits conclusions from this study**. **Finally**, we did not conduct a power analysis to determine the sample size. This is because the population from which well-trained soccer players can be drawn, belonging to the same team and with a common training background is limited. To overcome this problem, we conducted a within-subject design, and attempted to reduce learning curves by including familiarization sessions.

PRACTICAL APPLICATIONS

This study demonstrated that an 8-week intervention period, including either GPBT or SSGs training sessions twice a week, could improve physical capabilities of elite youth soccer players during the late-season period. GPBT and SSGs were equally effective in enhancing repeated sprint ability, **COD**, linear sprinting, jumping and intermittent running performances. In addition, the GPBT led to greater improvements in linear sprinting over 10-m and 20-m, while the SSGs training resulted in better vertical jumping and **COD** performances. During the in-season period, soccer coaches could prescribe either GPBT or SSGs training to continually develop soccer players' fitness components while also encompassing soccer-specific technical and tactical elements. In addition, GPBT and SSGs may be used as specific training methods for attempting long-term adaptations on short sprint, **COD** and jumping capabilities. These outcomes provide practitioners with training tools that, when applied as chronic interventions could help athletes in developing certain physical abilities according to the specific discipline and related playing demands.

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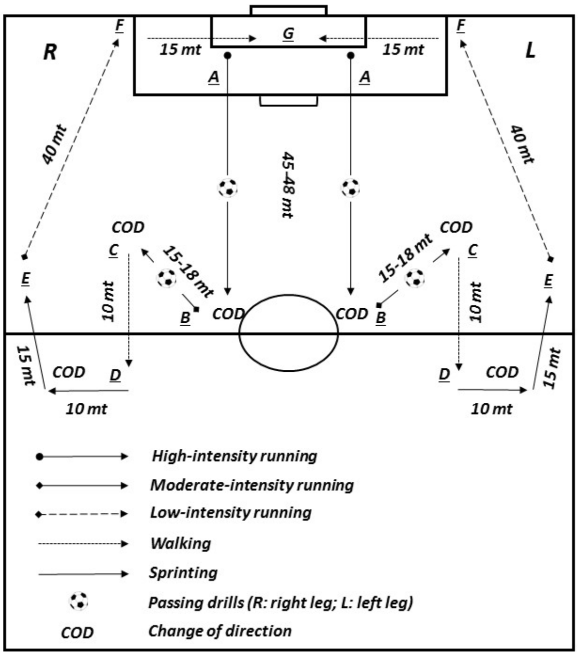
FIGURE LEGENDS

Figure 1: GPBT protocol setup.



GPBT PROTOCOL SETUP

- ***A-B + 1st COD (135°); High-intensity running at 105% of individual maximal aerobic velocity (MAV). Duration: ≈8 sec***
- ***B-C + 2nd COD (100°); Moderate-intensity running at 75% of individual MAV. Duration: ≈5 sec***
- ***C-D; Walking. Duration: ≈10 sec***
- ***D-COD (60°)-E; Sprints including one COD. Duration: ≈8 sec***
- ***E-F; Low-intensity running at 50 % of individual MAV. Duration: ≈20 sec***
- ***F-G; Walking. Duration: ≈10 sec***

NOTES:

- ***Each circuit bout lasts 1 min***
- ***Each set lasts 8 min***
- ***Between-set recovery: 3 min passive***