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Sequencing effects of small-sided games and high-intensity interval training on physical and physiological performance of young soccer players during pre-season

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Abstract

Study aim: This experimental study investigated the sequencing effects of a small-sided games (SSG) protocol and high-intensity interval training (HIIT) on the physical and physiological performance adaptation of soccer players, conducted over a fourteen-week of the pre-season.

Materials and methods: Twenty-three young (aged 14 ±0.1 years) male soccer players from a club participating in national-level competitions were randomly divided into two groups (SSG + HIIT, n = 11 and HIIT + SSG, n = 12). The first group completed SSGs (5 vs. 5 + goalkeeper, 36 × 30 m) followed by HIIT (long interval at 60 to 75% of final velocity during 30–15 intermittent fitness test) training, while the second group performed HIIT training and then SSGs. Assessments were conducted at baseline and post-intervention for 10 m linear sprint, body fat percentage, countermovement jump (CMJ), change of direction speed (CODS), squat jump (SJ), and Yo-Yo intermittent recovery test (Yo-Yo IR).

Results: A significant main effect of time was reported for 10 m linear sprint, CMJ, CODS, SJ, and Yo-Yo IR ($p \le 0.001–0.010$, $\eta_p^2 = 0.32–0.74$). However, no significant group × time interaction were reported for any dependent variables ($p = 0.433–1.000$, $\eta_p^2 \le 0.01–0.03$).

Conclusion: The sequencing order of HIIT and SSG does not affect the performance outcomes in young male soccer players. Moreover, similar improvements can be expected in the 10 m linear sprint, CMJ, CODS, SJ, and Yo-Yo IR, irrespective of the exercise order. However, caution should be taken when interpreting the within-group improvements, as the study did not include a control group.

Key words: Football – Aerobic fitness – Acceleration – Change of direction – Countermovement jump

Introduction

Soccer demonstrates its intermittent nature through short bursts of high-intensity activity, such as accelerations, decelerations, changes of direction, sprinting, and jumping, interspersed with longer periods of low-intensity actions like standing, walking, and jogging (Morgans et al., 2024). Benchmarking and profiling these physical characteristics is crucial for preparing players for match demands through effective training programs (French & Ronda, 2021). In addition, integrating physical and tactical demands has become increasingly important in recent years, with a growing focus on contextualising the physical performance of soccer players in relation to tactical activities (Morgans et al., 2023). Furthermore, soccer players are required to perform multiple high-intensity actions during the competition. Thus, it has been reported that maximum benefits can be achieved when the training stimulus mirrors the needs of the competition (Kavanagh

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et al., 2024). Therefore, to meet the required physical, technical, and tactical demands of soccer, coaches need to implement various drills on differing pitch sizes to promote these attributes (Weldon et al., 2022). One of the most common soccer-specific practices to achieve these attributes is small-sided games (SSG; i.e., playing soccer games in reduced pitch sizes) (Clemente, Afonso, et al., 2021), with the intensity of the SSGs being manipulated by factors such as field size, number of players, and duration of games (Hill-Haas et al., 2009).

Over the last decade, SSGs have gained increasing attention from soccer researchers, drawing conclusions that SSGs effectively modify physiological responses, develop tactical and technical skills, and align closely with match conditions (Castagna et al., 2009). Numerous studies (Almeida et al., 2013; Casamichana & Castellano, 2010; Hill-Haas et al., 2009) have observed that players exhibit higher rates of ball possession, ball handling, passing, direction changes, dribbling, scoring, tackling, intercepting, and engaging in 'off-the-ball' activities in condensed play scenarios, regardless of differences in skill level, age, experience, or gender. Therefore, coaches often adopt this training method to simulate match-play conditions by incorporating various pitch sizes, player numbers, and conditions (Clemente, Afonso, et al., 2021). In addition, SSGs are also suggested to improve both aerobic and anaerobic performance (Clemente et al., 2014; Moran et al., 2019). For example, one meta-analysis (Hammami et al., 2018) reported SSGs induced significant improvement (compared to control and specific control) in the change of direction (COD) speed, intermittent endurance (i.e. Yo-Yo test), jump height, linear sprint (10 m and 20 m distance), maximal oxygen uptake, and repeated sprint ability. However, the use of SSGs for physical performance development has also gained some criticism, with studies reporting movement differences in mechanical work related to ball movement, within-player variability across similar sessions, as well as variations in position-specific external load compared to match demands (Clemente, 2020; Lacome et al., 2018). In addition, the most demanding locomotor skills during a soccer match, which are also often related to injury (e.g., high-speed running with hamstring injury), are difficult to ensure during SSG formats (e.g., number and distance of high speed running in competitive games are two-fold the values recorded during SSGs) (Clemente, 2020).

To overcome the limitations of SSGs, an alternate training method is the running-based high-intensity interval training (HIIT), which is considered an effective strategy to target the mechanical work and high-speed running demands and significantly improve young soccer players' cardiorespiratory fitness levels (Laursen & Buchheit, 2019). This is possible due to the pre-defined course in running-based HIIT, where the coaches have control over the variables used in the course (e.g., including change of direction). Furthermore, HIIT is divided into several distinct categories: long intervals, short intervals, sprint intervals, repeated sprint intervals, and game-based (Curtis et al., 2019). This classification system enables coaches and athletes to precisely tailor training programs, focusing specifically on enhancing aspects of cardiorespiratory fitness and overall performance (Curtis et al., 2019; Laursen & Buchheit, 2019). When designing an effective HIIT program, it is essential to account for various factors, such as the ratio of exercise to rest, intensity levels, the duration of each series, and locomotor patterns (Buchheit & Laursen, 2013). However, the crucial elements to maximise training efficacy are the intensity and duration of the exercise intervals (Laursen & Buchheit, 2019). Albeit the positive benefits, SSGs are more enjoyable compared to running-based HIIT among youth soccer players (Harrison et al., 2015; Selmi et al., 2020).

Considering the benefits and limitations of both training methods, a pragmatic approach would be to combine both SSG and HIIT. Indeed, multiple studies have researched the combined effects of SSG and HIIT, with studies reporting contrasting findings (F. M. Clemente & H. Sarmento, 2021). For example, one study reported that combining SSG and HIIT was superior in improving physical fitness (e.g. VO2 peak) compared to performing SSG alone (Harrison et al., 2015). However, another study has reported no significant difference between the combined training approach and SSG alone in improving physical fitness (Castillo et al., 2021). In addition, one study (Paul et al., 2019) compared 1 versus 5 weekly SSG+HIIT sessions and reported improvements in endurance performance after 5 weekly sessions. Of note, several inconsistencies exist in the literature, and a lack of research examining the combined effects of both training modalities for adolescent soccer players is evident, particularly in the sequence of SSG and HIIT. As per the author's knowledge, only two studies (Arslan et al., 2021; Rabbani et al., 2019) compared the effects of the sequencing order of SSG and HIIT and reported similar improvements in performance adaptation after both sequencing orders. However, one study reported significantly lower perceived exertion and greater physical enjoyment when HIIT was performed prior to SSG (HIIT+SSG) compared to HIIT performed after SSG (SSG+HIIT). In addition, the study (Arslan et al., 2021) also reported a higher training load in the SSG+HIIT group compared to the HIIT+SSG group, suggesting the sequencing order of SSG and HIIT as important factors, considering that one may induce fatigue that affects the next (Van Cutsem et al., 2017). Moreover, the previous studies were conducted for either 4 weeks (Rabbani et al., 2019) or 6 weeks (Arslan et al., 2021) duration. Therefore, this study aimed to investigate the effects of sequencing order of SSGs and HIIT intervention across a 14-week intervention on the physical and physiological performance of elite young soccer players. Based on the existing evidence (Van Cutsem et al., 2017), the study hypothesis is that differences in physical and physiological performance adaptations will be evident between both training sequence groups.

Materials and methods

Study Design

The present study was conducted during the pre-season (June to July 2022) and in-season (August to November 2022), involving players from an Iranian Premier League club. This study lasted 16 weeks and included the first week as a pre-test, 14 weeks of the intervention, and the final week as a post-test (Figure 1).

Using research randomization software (www.randomizer.org) with an allocation ratio of 1:1, players were randomly divided into two groups (SSG + HIIT, n = 11) and (HIIT + SSG, n = 12). The first group completed SSG (5 vs. 5 + GK, 36 × 30 m) followed by HIIT (long interval at 60–75% of final velocity at the 30-15 Intermittent Fitness Test [30-15 VIFT]) training. The second group performed HIIT training, and then the SSG was performed across 14 weeks during the pre-season, consisting of one training session. All data collated resulted from normal analytical procedures regarding player monitoring over the competitive calendar.

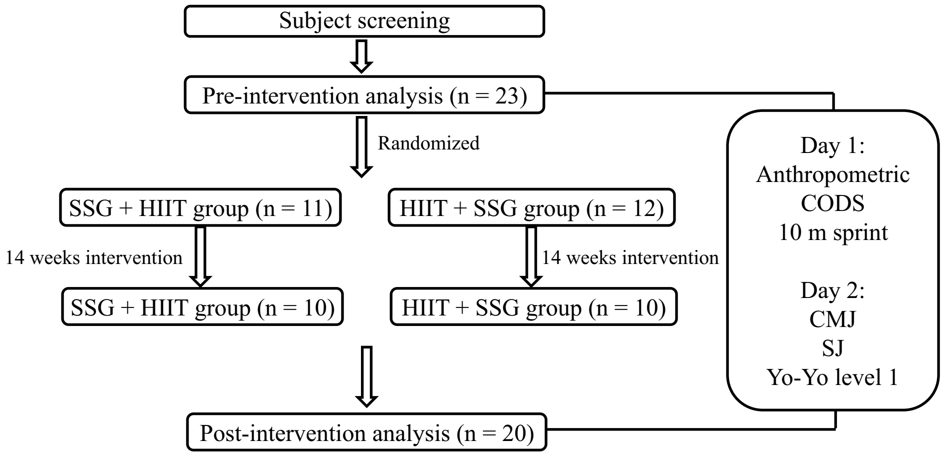

Figure 1. Flowchart study design

Participants

The participants were recruited from a single soccer club using a convenience sampling method. Twenty-three young male U14 soccer players from an Iranian Premier League club (age: 14±0.1 years, height: 165.9±6.9 cm, body mass: 51.4±6.1 kg), with at least four years of playing experience, participated in this experimental study. Six of the sample cohort were members of the U14 national team. The participants had four training sessions and one match per week and can be considered 'Tier 2' level (i.e., trained/developmental) based on the Participant Level Classification Framework (McKay et al., 2022). To conduct SSG and ensure that no group had multiple players in the same position, using a stratified randomisation process, players were grouped according to positions and then randomly allocated to two sub-groups: an SSG group (SSG + HIIT, n = 11; 4 defenders, 4 midfielders and 3 attackers), and a second group of HIIT (HIIT + SSG, n = 2; 4 defenders, 4 midfielders and 4 attackers). Players were also classified into five groups based on playing positions: central defenders (CD; n = 4), full-backs (FB; n = 4), central midfielders (CM; n = 8), wide midfielders (WM; n = 4), and forwards (FW; n = 3). Table 1 presents the participant's information. The G*Power software (version 3.1) was used to estimate the sample size (Faul et al., 2007). A minimum sample size of 14 was required to achieve statistical significance. The sample size was estimated for repeated measures within-between interaction, using effect size (f) = 0.41, power = 0.80, number of groups = 2, number of measurements = 2, correlation among repeated measures = 0.5, non-sphericity correction = 1, and p-value = 0.05. The effect size (f) was calculated in the G*Power software using the partial eta squared value of 0.145 obtained for the 10 m linear sprint in the study Arslan et al. (2021).

All participants were selected through the club's talent identification process and underwent a technical assessment before the commencement of the testing period. This preliminary evaluation ensured that each player was technically able to participate in the study.

The inclusion criteria for the study have been previously implemented (Morgans et al., 2023), and included: (i) listed on the roster of the U14 squad at the start of the season, (ii) regularly trained with the respective team, (iii) participated in at least 80% of training sessions and matches (Morgans et al., 2025), (iv) did not use dietary supplements during the study, (v) who were uninjured over the course of the study, and (vi) who did not participate in another training program along with this study. Additionally, the exclusion criteria for the study included: (i) long-term injured player data, (ii) players joining the team late in either of the study seasons, (iii) lack of full, complete data for training or match-play, and (iv) goalkeepers, due to the different variations in the physical demands with outfield players.

Table 1. Demographic information of participants

Characteristics	SSG + HIIT	HIIT + SSG	Overall
Participants (n)	11	12	23
Participants excluded* (n)	1	2	3
Age (years)	14±0.1	14±0.2	14±0.1
Experience (years)	4.0±3.0	4.0±2.0	4.0±2.0
Height (cm)	166.2±7.3	165.6±6.6	165.9±6.9
Body mass (kg)	51.4±6	51.4±6.3	51.4±6.1
Body mass index (kg/m^2)	15.12±1.4	15.47±1.2	15.29±1.3
Defenders (n)	4	4	8
Midfielders (n)	4	4	8
Attackers (n)	3	4	7
Adherence (%)	99	98	97

* Due to injuries, sickness, or drop-out

The study was conducted according to the requirements of the Declaration of Helsinki and was approved by the local Ethics Committee of the University of Isfahan and the club from which the participants volunteered. To ensure confidentiality, all data were anonymised before analysis. Before participation, all players and parents or guardians, were provided with detailed information, methods, and possible risks. Written informed assent and consent was obtained from both the participant and parent/guardian to ensure participation was entirely voluntary.

Test procedures

The assessments were conducted over two days from 9:00 AM to 11:00 AM. During the morning session, all participants were measured for standing and sitting height and body mass according to the American College of Sports Medicine guidelines (Pescatello, 2014). A ~15-minute warm-up routine consisting of a dynamic range of movement exercises were undertaken before each testing session. A ~3-minute recovery after the warm-up routine was provided to exclude the influence of acute fatigue. Following the warm-up routine, the participants then performed all the assessments.

The evaluations of this study were performed using a pre-post-test method during the competition season. Participants were already familiarised with the test protocols as a part of their regular testing and hence familiarisation sessions were not conducted. On day 1 of testing, standing height, body mass, and fat mass measurements were conducted in accordance with the standard protocols (Pescatello, 2014). On the same day, the change of direction (5-0-5 test) test and 10 m linear sprint test were conducted. On the second day, participants were evaluated for countermovement jump (CMJ), squat jump (SJ), and an aerobic power test using the Yo-Yo Intermittent Recovery Test – level 1 (YYIRT). The 30-15 intermittent fitness test (IFT) was conducted 48 hours after the final testing day. In addition, the data from 30-15 IFT was used only to design the training protocol (running-based HIIT). All testing protocols were conducted with at least 48 hours of rest and recovery after the last training session or match. The assessments were conducted by certified professionals (e.g., ISAK certified) who were part of the soccer club and were also blinded to the intervention.

Standing height

An ISAK-certified (International Society for the Advancement of Kinanthropometry) sports science staff member conducted the measurements of the players' standing height. Standing height was measured to the nearest using a stadiometer with an accuracy of ± 0.15% (Seca 700, Hamburg, Germany). To measure height, players stood against a wall with shorts and t-shirts and did not wear shoes or socks. These measurements were carried out in accordance with the protocols established by ISAK (Norton, 2018).

Body mass

Body mass for each participant was recorded in a fasted state by ISAK-certified staff between 08.00 and 12.00. Participants were instructed not to eat after 22.00 the previous night and to avoid exercise for 12 hours before the assessment. Body mass was measured using a calibrated electronic scale with an accuracy of ± 0.15% (Seca 700, Hamburg, Germany). Participants wore minimal clothing and no shoes, with measurements noted to an accuracy of 0.01 kg, as outlined in previous studies (Slaughter et al., 1988).

Skinfold measurements

Skinfold thickness was measured by ISAK-certified testers, and the values were then used to subsequently compute an estimate of body fat percentage using the Slaughter skinfold prediction equation. Participants were instructed to arrive in a fasted state for this assessment. Measurements were taken three times at two sites (i.e., triceps and calf), and the average was used for the body fat prediction (Jagim et al., 2024). The first measurement was taken on the triceps, positioned vertically on the back of the arm, equidistant between the acromial process at the top of the shoulder and the olecranon process at the elbow. The second measurement occurs on the calf, specifically on the medial side of the right lower leg at the point of greatest calf circumference (França et al., 2023). A body mass measuring device (Harpenden, United Kingdom) was utilised to assess the players.

Boys: % Body Fat = 0.735 (Triceps + Calf) + 1.0

Sprint test

Participants began with a standardised warm-up, followed by two 10 m sprint trials performed on an artificial grass surface. Following each sprint, a three-minute rest interval was provided. Timings were measured using a valid and reliable single-beam electronic timing gate system (SmartSpeed® Pro-timing lights, Fusion Sport, Finland), which were positioned at the start and end of the 10 m track. The timing gates were installed 1 m above the ground, and each sprint was timed to an accuracy of 0.01 seconds. Participants started 30 cm behind the first timing gate with a two-point stance. Participants were instructed to exert maximum effort during each sprint. All participants were familiar with the sprint test protocols due to participation in several practice sessions. Two trials were conducted, and the fastest 10 m sprint time was used for analysis. The coefficient of variation (CV) was 1.33% and interclass correlation coefficient (ICC) with 95% confidence interval was 0.99 (0.98–1.00) for test-retest.

Change of direction

The 505-COD test was performed in accordance with standardised procedures (Ja, 1985). Following the sprint trials and five minutes of recovery, the 505-COD test was performed. Participants completed two repetitions, from a two-point athletic position; the procedure included a 15 m sprint from a stationary start, followed by a 180° turn at a specified turning leg (either right or left; self-selected by the participants), ensuring contact with a marked line. After making the turn, participants completed a 5 m sprint back to the designated finish line. The time taken to complete the final 5 m of the initial sprint, the turn, and the return sprint was recorded. The same leg was used for pre- and post-intervention assessments by the participants. The same electronic timing gates used for linear sprint (SmartSpeed® Pro-timing lights, Fusion Sport, Finland) were utilized for the 505-COD test. The timings gates were placed at the 10 m mark and at a height of 1 m. Two trials were conducted, and the best time was selected for analysis. The CV was 0.72%, and the ICC with 95% CI was 0.98 (0.94–0.99) for the test-retest.

Aerobic fitness status

The Yo-Yo Intermittent Recovery Test – level 1 (YYIRT)

Participants start from a stationary position and run towards the opposite cone (20 m distance). Upon reaching the cone, participants turn and run back to the starting cone. An active rest is performed between two cones (5 m apart) for 10 seconds. The rest period involves low-intensity jogging or walking to allow partial recovery (Silva et al., 2022). The sound of the audio controlled the speed of running and rest time. Each participant is allowed two warnings If the tester does not reach the finish line before the beep is sounded, he will be warned and removed after two warnings. This test is completed once the individual completes it within a certain period of time, and the results are documented.

Vertical Jumps

Jump height data were collected for countermovement Jump (CMJ) and squat jump (SJ), both performed without arm swing. All participants were already familiar with the jumping protocols (as part of the weekly team evaluations). Participants also participated in multiple practice testing sessions. All jump tests were conducted in an indoor facility using a contact platform to eliminate any potential external variations in surface that might influence the outcomes. To standardise the jump tests, participants were instructed to adhere strictly to the defined protocols during all attempts. Two trials were conducted for both jump tests, and the highest jump was selected for analysis. The test-retest CV was 3.92% for CMJ and 3.63% for SJ and the ICC with 95%CI was 0.99 (0.97 – 1.00) for CMJ and 0.98 (0.94 – 0.99) for SJ, respectively.

The 30–15 Intermittent Fitness Test

The 30–15 IFT consists of shuttle runs between two lines 40 m apart, with running intervals of 30 seconds followed by 15-second rest periods. The test begins at a speed of 8 km/h, which increases by 0.5 km/h every 30 seconds, with the pace set by pre-recorded audio beeps. Athletes were encouraged throughout the test to push their limits and complete as many stages as possible. The test concluded when the athlete either reached exhaustion and stopped voluntarily or failed to reach the 3 m mark at the beep on three consecutive attempts. The highest running speed reached before termination was recorded as the VIFT, which was used as a training prescription variable during HIIT sessions (Buchheit, 2008).

Training protocol

Each week, the team completed four training sessions with the same exercises for both groups. In the first group, the training consisted of three minutes of SSG, followed by a 3-minute rest, and then three minutes of HIIT. The second group completed the training structure in the reverse order: three minutes of HIIT, three minutes of rest, and then three minutes of SSG. During HIIT, the intensity was set based on each player's individualized functional threshold that was calculated using the highest running speed reached before the termination of the 30-15 IFT. This speed, denoted as VIFT, is a critical measure used to assess an athlete's maximum aerobic capacity and endurance. The training was designed to be effective by using the 30-15 IFT protocol (Buchheit, 2008). The training sessions consisted of five minutes of general warm-up and 15 to 20 minutes of specific warm-up activities. Immediately following the warm-up, the main exercises were conducted, completing the session with 10 to 15 minutes of gentle running and stretching movements. Table 2 present the detail training protocol used during the intervention.

Table 2. Summary of the 14-week training programs

Week	Game Formats	Pitch Dimension	SSG	HIIT
1			Per-Intervention Testing	
2	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 60% of VIFT)
3	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 60% of VIFT)
4	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 65% of VIFT)
5	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 60% of VIFT)
6	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 65% of VIFT)
7	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 65% of VIFT)
8	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 70% of VIFT)
9	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 65% of VIFT)
10	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 70% of VIFT)
11	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 70% of VIFT)
12	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 75% of VIFT)
13	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 70% of VIFT)
14	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 75% of VIFT)
15	5 × 5	36 × 30	2 × (3 min of 5 vs 5 + GK)	2 × (3 min long at 75% of VIFT)
16			Post-Intervention Testing	

Abbreviations: HIIT: high-intensity interval training; SSG: small-sided game; GK, goalkeeper; Vift, velocity of intermittent fitness test.

Statistical analysis

Data are presented as mean and standard deviation. Normality assumptions of the data were verified using the Shapiro-Wilk test. A two-step approach was utilised to transform non-normally distributed data into a normal distribution for parametric testing (Templeton, 2011). Two (pre versus post) by two (SSG + HIIT versus HIIT + SSG) mixed design analysis of variance was used to analyse the main effect of time and the interaction effects. Partial eta squared (η_p^2) derived from the ANOVA output were used as effect size (ES) for the main effect of time and interaction effects. In addition, paired t-tests were also conducted to assess the within-group changes. For within-group changes, Hedges'g was used as ES and calculated using the mean and standard deviation from pre- and post-assessments for each variable using a customized Microsoft Excel Sheet. Percentage change scores were also calculated for each variable in each group using the equation in the Microsoft Excel sheet: [(mean post – mean pre)/mean pre] × 100. The effect size of η_p^2 was interpreted as small (<0.06), moderate (≥0.06–0.13), and large (≥0.14) (Cohen, 1988), while Hedge's g was interpreted as trivial (<0.2), small (0.2–0.6), moderate (>0.6–1.2), or large (>1.2–2.0) (Hopkins et al., 2009). Statistical significance was set at $p \leq 0.05$.

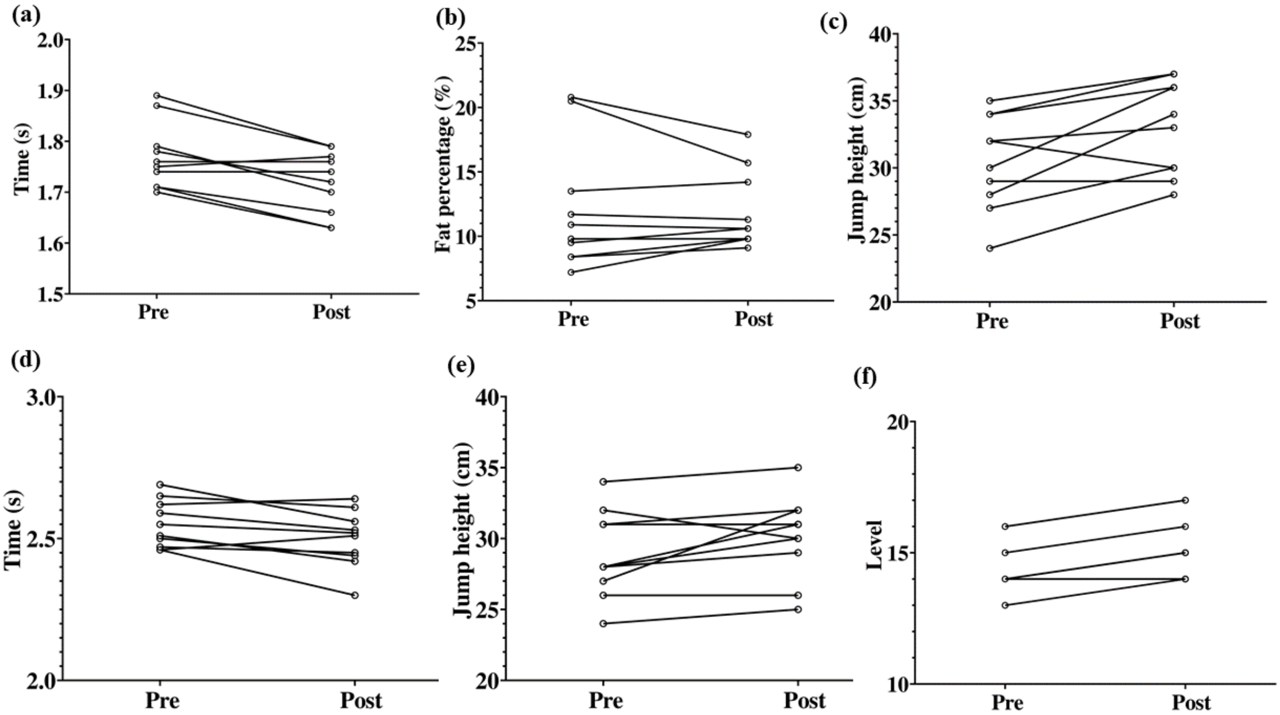

Figure 2. Individual responses (lines) for (a) 10-m linear sprint time, (b) body fat percentage, (c) countermovement jump height, (d) change-of-direction speed time, (e) squat jump height, and (f) Yo-Yo test level from pre- to post-intervention with small sided games performed prior to high-intensity interval training (SSG+HIIT).

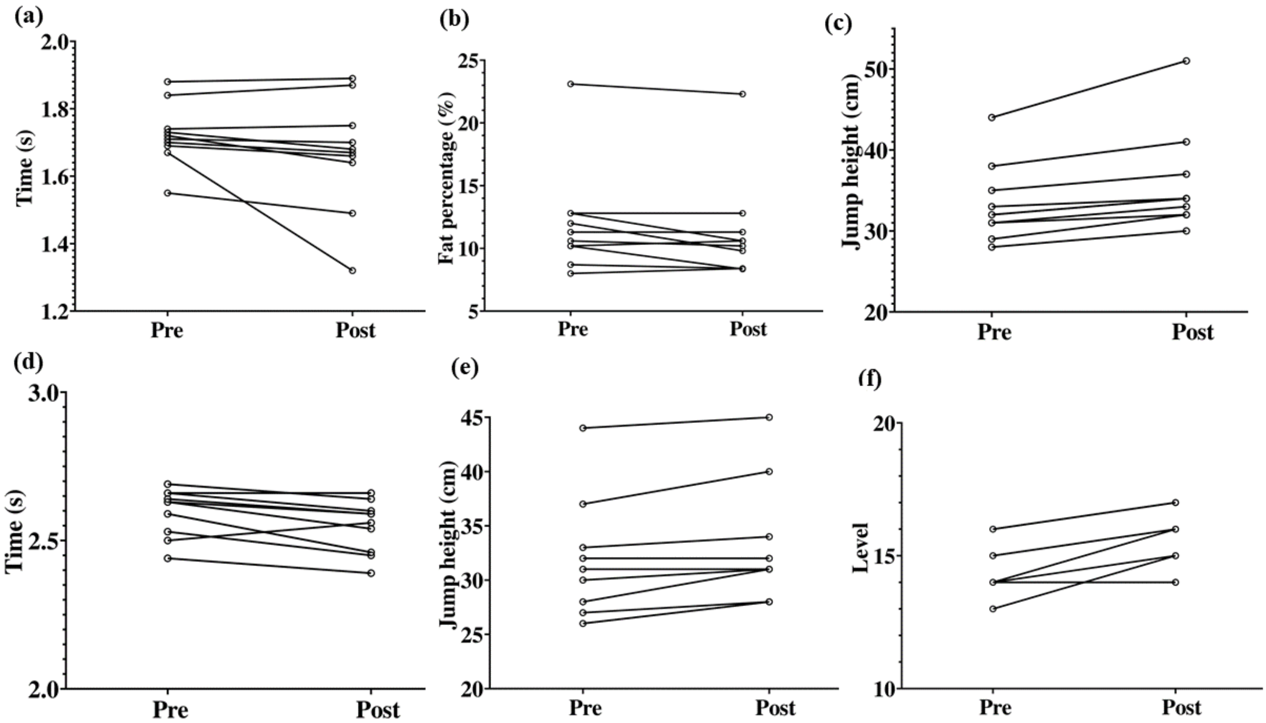

Figure 3. Individual responses (lines) for (a) 10-m linear sprint time, (b) body fat percentage, (c) countermovement jump height, (d) change-of-direction speed time, (e) squat jump height, and (f) Yo-Yo test level from pre- to post-intervention with high-intensity interval training performed prior to small sided games (HIIT+SSG).

Results

No significant difference was reported at baseline for 10 m linear sprint ($p = 0.199$), body fat ($p = 0.961$), CMJ ($p = 0.150$), CODS ($p = 0.218$), SJ ($p = 0.232$), and Yo-Yo IR ($p = 0.517$). Significant baseline difference was reported for COD deficit ($p = 0.014$).

Within-group analyses

Significant trivial to moderate improvements were observed in CMJ ($p = 0.002$, $g = 0.69$, $\Delta\% = 8.2$), CODS ($p = 0.011$, $g = 0.07$, $\Delta\% = 2.4$), and SJ ($p = 0.023$, $g = 0.39$, $\Delta\% = 4.2$) in the SSG + HIIT group. For the HIIT + SSG group, significant trivial to small improvements were observed in the 10 m sprint ($p = 0.046$, $g = 0.09$, $\Delta\% = 3.5$), CMJ ($p = 0.002$, $g = 0.44$, $\Delta\% = 7.5$), CODS ($p = 0.015$, $g = 0.06$, $\Delta\% = 1.93$), and SJ ($p = 0.010$, $g = 0.57$, $\Delta\% = 9.33$). The individual response to training intervention are presented in Figure 2 and 3, respectively.

Main effect of time

A significant large effect of time was observed in 10 m linear sprint ($F = 8.38$, $p = 0.010$, $\eta_p^2 = 0.32$), CMJ ($F = 27.11$, $p < 0.001$, $\eta_p^2 = 0.60$), COD ($F = 15.24$, $p < 0.001$, $\eta_p^2 = 0.46$), SJ ($F = 14.49$, $p = 0.001$, $\eta_p^2 = 0.45$) and Yo-Yo IR test ($F = 52.07$, $p < 0.001$, $\eta_p^2 = 0.74$). No significant main effect of time was observed for body fat percentage ($F = 1.36$, $p = 0.259$) and COD deficit ($F = 0.019$, $p = 0.891$).

Group × time effect

No significant group × time interaction was observed for any dependent variables (all $p > 0.05$). Detailed statistical outcomes are displayed in Table 3.

Table 3. Statistical outcomes for both experimental groups

Dependent Variables	Group	Baseline	Post 14 Weeks	Hedge's g	Main Effect: Time			Interaction: Time × Group		
		Mean ± SD/median (IQR)			F	p	η_p^2	F	p	η_p^2
10 m sprint (s)	SSG+HIIT	1.77 ± 0.6	1.71 ± 0.6	0.10	8.38	0.010	0.32[L]	0.018	0.894	<0.01[S]
	HIIT+SSG	1.72 ± 0.9	1.66 ± 0.2*	0.09						
Body fat (%)	SSG+HIIT	10.4 ± 6.9	10.6 ± 4.8	0.05	1.36	0.259	0.07[M]	0.44	0.515	0.02[S]
	HIIT+SSG	11.0 ± 3.0	10.4 ± 3.3	0.16						
CMJ (cm)	SSG+HIIT	30.5 ± 3.4	33 ± 3.5*	0.69	27.11	<0.001	0.60[L]	<0.01	1.000	<0.01[S]
	HIIT+SSG	33.3 ± 4.7	35.8 ± 6.1*	0.44						
CODS (s)	SSG+HIIT	2.55 ± 0.80	2.49 ± 0.90*	0.07	15.24	<0.001	0.46[L]	0.01	0.909	<0.01[S]
	HIIT+SSG	2.59 ± 0.80	2.54 ± 0.90*	0.06						
COD deficit (s)	SSG+HIIT	0.78 ± 0.07	0.78 ± 0.10	0.00	0.019	0.891	<0.01[S]	0.03	0.856	<0.01[S]
	HIIT+SSG	0.87 ± 0.08	0.88 ± 0.17	0.07						
SJ (cm)	SSG+HIIT	28.9 ± 3.0	30.1 ± 2.9*	0.39	14.49	0.001	0.45[L]	0.09	0.773	<0.01[S]
	HIIT+SSG	30.0 ± 3.7	31.0 ± 7.5	0.57						
Yo-Yo IR 1	SSG+HIIT	14.0 ± 1.25	15.0 ± 2.25	0.73	52.07	<0.001	0.74[L]	0.643	0.433	0.03[S]
	HIIT+SSG	14.7 ± 1.0	15.7 ± 1.1	0.91						

Note: * - significant difference from pre to post, η_p^2 – partial eta squared, CMJ: Counter-Movement Jump, CODS: change of direction speed, SJ: Squat Jump, HIIT: High-intensity interval training, [L] – large, [M] – moderate, [S] – small, [T] – trivial, SSG: Small-sided Games.

Discussion

The aim of the study was to compare the sequencing effects of HIIT and SSG on 10 m linear sprint, body fat percentage, CMJ, COD, SJ, and Yo-Yo IR tests. The findings suggest that a combination of HIIT and SSG can improve 10 m linear sprints, vertical jumps (i.e., CMJ and SJ), COD, and Yo-Yo IR test performance. However, when comparing the sequencing effects of HIIT and SSG, no significant between-group difference was reported for any dependent variables.

Our finding showed that a combination of SSG and HIIT (irrespective of the sequence) significantly improves the physical performance of soccer players, which is in line with previous studies (Arslan et al., 2021; Clemente, Afonso, et al., 2021; Rabbani et al., 2019). The linear sprinting and COD performance improvement may be due to the neuromuscular demand imposed by combining SSG and HIIT (Hammami et al., 2018; Thapa et al., 2023). It is also important to note that, although SSG has been shown to induce COD demands in Australian football (Davies et al., 2013), and researchers have used the positional data from SSG to quantify COD demands in soccer (Merks et al., 2022), a recent meta-analysis has shown no improvement in linear sprints and COD after SSG intervention (Clemente, Ramirez-Campillo, et al., 2021), thereby implicating the importance of combined training approach (Arslan et al., 2021). Such an approach combining SSG and HIIT may complement the limitations of each training method (F. Clemente & H. Sarmento, 2021; Clemente, Ramirez-Campillo, et al., 2021). For example, SSG may impose less sprinting demand due to small-sized pitches compared to normal games (Clemente, 2020), which can be complemented by HIIT, which includes sprinting demands (Clemente, Ramirez-Campillo, et al., 2021). One study (Arslan et al., 2021) also reported significant improvement in sprint and COD after a 6-week combined SSG and HIIT training approach. Of note, no changes were reported in COD deficit in the current study. This may be indicative of the participants improving their COD test performance due to the improvement in linear sprint ability and not due to their ability to change directions. However, this remains speculative, as previous studies (Arslan et al., 2021; Rabbani et al., 2019) did not measure the COD deficit.

In addition, the vertical jump also improved after the combined training approach. Although non-significant, a meta-analysis reported favouring effects of both HIIT and SSG training on vertical jump improvement (Clemente, Ramirez-Campillo, et al., 2021). It is important to note here that the meta-analysis included studies with interventions ranging from 4 to 8 weeks in duration (Clemente, Ramirez-Campillo, et al., 2021), whereas the intervention in our study was 14 weeks in duration. A longer intervention may have imposed sufficient neuromuscular demand to improve the lower limb power. In addition, the players also performed speed, agility, and quickness training involving jump-training stimulus as part of their regular training, which has been shown to improve the CMJ and SJ performance (Ramirez-Campillo et al., 2023; Thapa et al., 2024; Uysal et al., 2022). Moreover, a significant improvement in the Yo-Yo IR test (i.e., aerobic capacity) was also observed after combined training. This finding is anticipated as both SSG and HIIT aim to target the metabolic pathways (i.e., aerobic and anaerobic) (Hill-Haas et al., 2011). Indeed, a previous meta-analysis have also shown both HIIT and SSG to be equally effective in improving the aerobic capacity of soccer players (Kunz et al., 2019), further supporting our findings. Of note, the participants in our study were players with an average age of 14 years. Although we did not assess the maturation level of the participants, it may also be possible that the effects of maturation may have affected the physical fitness outcomes mentioned above (e.g., sprints, jumps) (Katzmarzyk et al., 1997).

Furthermore, when the sequence was compared, no between-group differences were observed for any of the dependent variables. These findings are in line with previous studies that compared the sequencing effects of SSG and HIIT (Arslan et al., 2021; Rabbani et al., 2019). For example, Rabbani et al. (2019) compared SSG + HIIT versus HIIT + SSG sequence and reported similar improvement in 30–15 intermittent fitness tests, which is similar to our findings on Yo-Yo IR tests. Another study that compared SSG + HIIT versus HIIT + SSG sequencing reported similar improvements in linear sprint, CMJ, CODS, and Yo-Yo test (Arslan et al., 2021). These findings suggests that there are no specific effects of order of SSG and HIIT, when similar training load is applied.

Limitations and future research

This study has several limitations that must be acknowledged. Firstly, the sample size was relatively small and limited to a specific group of soccer players, which may affect the generalizability of the findings to a wider population of athletes (e.g., adults or female players). Secondly, this study was conducted during the pre-season period, and only one session per week was used for this intervention. Therefore, how a higher frequency (e.g., 2 or 3 sessions per week) intervention during the preparatory period would affect the outcomes needs further investigation. Thirdly, this study relied on specific performance measures, and other important variables, such as the internal and external training load and psychological factors (e.g., player motivation), were not measured. Fourthly, the age and experience of the participants can affect the interpretation of the results and should not be extrapolated to other populations. Lastly, the maturation of the participants was not assessed during the intervention period. The improvements in the physical performance of participants involved in the current study may also be due to the process of maturation; hence, assessing maturation would further assist in the interpretation of the findings. Moreover, a control group consisting of participants of similar ages and competitive levels would further assist in the interpretation of such findings.

Future research should address these limitations by including a larger and more diverse sample of soccer players in order to increase the generalizability of the findings. Expanding the scope of performance measures to include psychological factors and player motivation can provide a more comprehensive understanding of practice effects. In addition, future research should examine genetic, nutritional, and recovery factors. In addition, the moderating effects of such sequencing on the technical and tactical aspects of players during a competitive period would add additional insight. Finally, investigating the optimal sequence and integration of SSG and HIIT at different stages of the training season can provide valuable insights for coaches and practitioners.

Practical applications

The findings of this study offer valuable insights for soccer coaches, trainers, and sports scientists seeking to optimise the players' physical and physiological performance through effective training strategies. The following practical applications can be derived from the study: Coaches can include both SSG and HIIT in the weekly training to improve players' physical and physiological performance. During the preparatory period, a single session of SSG and HIIT is sufficient to improve physical performance. Furthermore, the order of SSG and HIIT does not affect the performance outcomes and, thus, can be used interchangeably.

Conclusions

The sequencing order of HIIT and SSG does not affect the performance outcomes in young male soccer plyers. Moreover, 10 m linear sprint, CMJ, COD, SJ, and Yo-Yo IR1 can similarly improve with the combined training approach (i.e., HIIT and SSG), irrespective of the order of sequence in which they are performed. Based on logistical availability and coaches' preferences, the order of SSG and HIIT can be sequenced for improving performance, without any negative consequences.

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