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Effects of 8-Week Recreational Basketball and Soccer Training on Physical Fitness, Body Composition, and Psychological Responses in Untrained Adults: A Randomized Controlled Trial

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Article

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Abstract

To compare the effects of recreational soccer and basketball on physical fitness, body composition, and psychological responses in untrained young adults, this randomized controlled trial enrolled 45 participants (age: 19.82 ± 0.61 years) and allocated them 1:1:1 to soccer small-sided games (SSG), basketball small-sided games (BSG), or a control group (CG), with 15 per group. Both training groups underwent 3 sessions weekly for 8 weeks. The results demonstrated that SSG and BSG significantly improved BMI (-2.8% and − 2.7%, $p < 0.001$), lean body mass (-1.9% and − 1.8%, $p < 0.001$), 1RM squat (+ 7.4% and + 6.9%, $p < 0.001$), 20 m MFT (+ 19.8% and + 20.5%, $p < 0.001$), VO_2max (+ 10.0% and + 10.3%, $p < 0.001$), and repeated sprint variables (all $p < 0.001$), with no changes in CG (all $p > 0.05$). Both training groups outperformed CG in peak power ($p < 0.001$), mean power ($p < 0.01$), and fatigue index ($p < 0.05$), with no differences between SSG and BSG (all $p > 0.05$). Exercise enjoyment remained high in both groups, while basketball elicited higher initial perceived exertion and soccer required greater mental effort later. These findings demonstrate that both recreational basketball and soccer are equally effective in improving fitness in untrained young adults, with sustained enjoyment supporting their feasibility as public health tools.

Introduction

Physical inactivity and sedentary behavior have become major global public health concerns, closely associated with an increased risk of obesity, cardiovascular disease, type 2 diabetes, metabolic dysfunction, reduced muscular strength, and poor mental health outcomes[1,2]. Traditional exercise interventions, including continuous aerobic training and resistance exercise programs, are widely recommended to improve health and physical fitness[3,4]. However, long-term adherence to structured exercise programs remains relatively low among sedentary and untrained individuals, with common barriers including low motivation, monotony, perceived excessive exertion, lack of enjoyment, and low exercise self-efficacy[4,5]. Consequently, the development of exercise modalities that are both physiologically effective and psychologically pleasurable has become an important focus in exercise science and public health research.

Recreational team sports represent a promising and sustainable alternative to conventional exercise, as they integrate intermittent physical activity, social interaction, and intrinsic enjoyment [6–8]. Among team-based activities, recreational soccer and basketball are among the most popular and accessible forms of group-based physical activity worldwide. They are characterized by frequent high-intensity running, sprinting, rapid changes of direction, lateral movements, jumping, and continuous activity transitions, which impose comprehensive physiological demands on the body while simultaneously stimulating multiple components of physical fitness[1,9].

Research has demonstrated that recreational basketball elicits higher heart rate responses and greater physical activity intensities compared to high-intensity interval training (HIIT), with heart rate frequently exceeding 85% of maximum during active play[8,9]. Similarly, recreational soccer involves intermittent high-intensity actions, with approximately 900 activity changes per session, including short sprints, turns, jumps, and ball-related technical movements[10,11]. The intermittent high-intensity pattern of both sports, alternating with low-intensity recovery periods, places simultaneous demands on both aerobic and anaerobic metabolism. Consequently, these activities are highly effective for improving cardiorespiratory endurance, muscular endurance, speed, agility, and repeated sprint ability—key physical fitness components that underpin performance in team sport settings[12,13].

A growing body of evidence confirms that recreational soccer and basketball training elicit favorable health-related adaptations in untrained and sedentary populations. Meta-analytic evidence demonstrates that recreational soccer significantly improves cardiorespiratory fitness (VO_2 max) in previously inactive adults, with effects comparable to or greater than traditional endurance running[2,14]. Recreational small-sided soccer training has been shown to enhance body composition by reducing fat mass, lowering body mass index and waist circumference, and improving blood pressure and resting heart rate in untrained young adults[15–17]. Parallel beneficial adaptations have been reported following recreational basketball interventions, including improvements in cardiorespiratory fitness, body composition, muscular strength, jumping performance, and cardiovascular health markers[18,19]. Furthermore, small-sided recreational team sports allow modulation of exercise intensity through variations in player number, pitch or court size, and rules, making them suitable and tolerable for untrained individuals[11,20,21].

Beyond physical health benefits, recreational team sports are associated with high levels of exercise enjoyment, adherence, and psychological well-being[7,15,22]. Recreational 3×3 basketball and small-sided soccer elicit favorable affective responses, including low perceived exertion and high intrinsic motivation, driven by enjoyment, social engagement, and reduced monotony compared with structured exercise [19,22]. Such psychological benefits help overcome common barriers to long-term participation and support sustained physical activity behavior[15,23].

Despite the well-documented benefits of recreational soccer and basketball, direct comparisons between these two modalities in untrained adults remain scarce, particularly in randomized controlled trials assessing comprehensive physical fitness, body composition, and exercise enjoyment. Therefore, the present randomized controlled trial compared the effects of 8-week recreational basketball and soccer training programs on muscular strength, cardiorespiratory fitness, repeated sprint ability, body composition, and exercise enjoyment in untrained adults. We hypothesized that both interventions would produce comparable improvements across these outcomes.

Methods

Study design

A parallel controlled study design was employed. Participants were randomly assigned to one of three groups: the SSG group (n = 15), the BSG group (n = 15), or the blank control group (CG) (n = 15), which did not receive exposure to sided games (Figure 1).

Randomization was conducted prior to group allocation using a 1:1:1 ratio. Opaque envelopes were randomly assigned to participants, and a researcher allocated each player to an envelope corresponding to a specific group. Allocation concealment was maintained through rigorous randomization and sealed envelopes, thereby enhancing the reliability and impartiality of group assignment. Recruitment strategies included sending verbal invitations and reference letters to college students, distributing informational letters in common areas, and promoting via social media. Only evaluators were blinded to group assignments; neither participants nor training intervention administrators were blinded. Inclusion criteria required no prior exposure to recreational soccer, absence of acute or chronic illnesses, absence of injuries or ongoing treatments, adherence to strict discipline, and a compliance rate exceeding 85% for participants in the SSG and BSG groups at all assessment points. Written informed consent was obtained from all participants, who were thoroughly briefed on study procedures and potential risks. Participants in the experimental groups followed prescribed exercises, while those in the control group did not participate in any specific training regimen. The study duration was 8 weeks. Participants in the SSG and BSG groups trained three times per week and were evaluated one week before training commenced (week 1) and one week after training concluded (week 10). To promote fluency and enjoyment in mini-games, all participants completed an initial training phase consisting of eight 45-minute sessions focused on technical skills such as passing and dribbling.

Ethical

Ethical approval for this study was obtained from the Ethics Committee of Hunan Vocational College of Mechanical and Electrical Technology (Approval No.: 20260301, Approval Date: March 01, 2026). All participants provided written informed consent, and the study procedures strictly adhered to the ethical principles of the Declaration of Helsinki.

Participants

Sample size estimation was performed using G*Power software (version 3.1), with an effect size of 0.2, statistical power of 0.8, significance level of 0.05, and a correlation coefficient of 0.5, accounting for three groups and two measurements. The required sample size was calculated as 42. Ultimately, 45 individuals were enrolled in the study (mean age: 19.82 ± 0.61 years; mean height: 1.77 ± 0.04 meters; mean weight: 74.59 ± 7.80 kilograms). All participants reported engaging in no more than 90 minutes of moderate to low-intensity physical activity per week, thereby meeting the inclusion criteria. Following randomization, group characteristics are summarized in Table 1.

Daily physical activity was assessed using the short version of the International Physical Activity Questionnaire, administered both before and after the intervention. Baseline physical activity levels were comparable across all groups. No significant changes in physical activity were observed in the control group between pre- and post-intervention assessments. Adherence rates in both the SSG and BSG groups exceeded 90%, as verified by attendance records. Attendance at each training session was documented using registration forms. No participants withdrew from the study, and no additional encouragement or engagement strategies were employed beyond the participants' inherent commitment to training.

Table 1. General descriptive parameters.

	SSG (n = 15)	BSG (n = 15)	CG (n = 15)	Total (N = 45)
Age (years)	19.67 ± 0.62	19.87 ± 0.52	19.93 ± 0.70	19.82 ± 0.61
Height (m)	1.78 ± 0.04	1.77 ± 0.04	1.76 ± 0.04	1.77 ± 0.04
Body mass (kg)	74.09 ± 8.12	74.36 ± 8.39	75.32 ± 7.36	74.59 ± 7.80
BMI (kg/m²)	23.49 ± 2.78	23.82 ± 3.03	24.23 ± 1.69	23.85 ± 2.52

SSG: soccer small-sided games group; BSG: basketball small-sided games group; CG: control group; BMI: body mass index.

Training load monitoring

Heart rate (HR) was continuously recorded during all training sessions using Polar H10 heart rate monitors (Polar Electro, Kempele, Finland). Rating of perceived exertion (RPE) was assessed immediately after each session using the Borg CR-10 scale[24,25]. Participants were instructed to provide ratings based on their overall somatic sensations. The integration of HR monitoring and RPE enabled a comprehensive assessment of internal training load. Additionally, the 4-item short-form Physical Activity Enjoyment Scale (PACES-S)[26] and the Rating Scale for Mental Effort (RSME)[27] were administered immediately after each session to assess affective and cognitive responses to training. The PACES-S comprises four statements, such as “I enjoy it” and “It’s very pleasant,” each rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The RSME is a unidimensional visual analog scale represented by a 150-mm line anchored by nine verbal descriptors ranging from “absolutely no mental effort” to “extremely large mental effort.” The PACES-S has demonstrated excellent internal consistency and test–retest reliability in adult populations[28].

Training intervention

Soccer small-sided games (SSG)

The soccer small-sided games (SSG) intervention lasted 8 weeks, with three training sessions per week, each separated by at least 48 hours. Two match formats, 3v3 and 4v4, were alternated weekly. The 3v3 matches were played on a 20 m × 15 m artificial turf field with 2 m × 2 m goals, consisting of four 5-minute bouts with 2-minute passive rest intervals. The 4v4 matches used the same field and goal dimensions, comprising two 10-minute halves with a 3-minute halftime rest. Multiple spare balls were positioned around the field to ensure continuous play and minimize interruptions. Each session began with a 10-minute standardized warm-up (jogging, dynamic stretching, and joint mobilization) and ended with 5 minutes of cool-down stretching. Coaches provided

general verbal encouragement throughout the intervention. Participants were permitted to drink water freely during rest periods to maintain physiological comfort and standardize experimental conditions. No technical or tactical instruction was given during matches.

Basketball small-sided games (BSG)

The basketball small-sided games (BSG) group followed an identical 8-week schedule, with two sessions per week separated by at least 48 hours, and used the same weekly 3v3 and 4v4 alternating format as the SSG group. The 3v3 matches were played on a standard half basketball court, divided into four 5-minute quarters with 2-minute rest intervals. The 4v4 matches were conducted on the same half-court, structured as two 10-minute halves with a 3-minute halftime rest. Both formats resulted in a total effective game duration of 20 minutes per session. Standard basketball rules were applied, with the additional requirement that teams attempt a shot within 15 seconds of gaining possession to maintain training intensity. Multiple basketballs were placed around the court to ensure continuous play. The same 10-minute warm-up and 5-minute cool-down protocol was used. Coaches provided general verbal encouragement but did not offer technical or tactical guidance. A complete overview of training parameters is provided in Table 2

Measurement procedure

Three professional trainers conducted the assessments, with testing beginning at 5 pm each day under average temperatures of 20° to 25°. Players received instructions on the testing procedures and were divided into three groups. Measurements were performed sequentially over four consecutive days, with daily schedules designed to minimize interference between assessments. On the first day, anthropometric and body composition indices, including height, weight, body mass index (BMI), and lean body mass, were measured. The second day focused on lower limb maximal strength, assessed using the one-repetition maximum (1RM) squat test. Cardiorespiratory endurance was evaluated on the third day using the 20-meter multistage shuttle run test. The fourth day was reserved for the repeated sprint ability test (RAST).

To ensure comparability and stability of results across groups, the experimental procedures maintained consistent site arrangements, equipment placement, and standardized testing protocols throughout the study. Participants were instructed to avoid strenuous exercise within 24 hours prior to each test, obtain 7 to 8 hours of sleep per night, and consume an appropriate amount of easily digestible carbohydrates one hour before testing to minimize the effects of fasting or overeating on test outcomes.

Anthropometric assessment

Standardized anthropometric measurements were obtained using professional equipment. Height was measured with a portable stadiometer (SECA 213, Hamburg, Germany; accuracy: 0.1 cm), and weight was measured with a portable electronic scale (SECA 760, Hamburg, Germany; accuracy: 0.1 kg). To ensure data accuracy, participants fasted, emptied their bladders and bowels, removed personal accessories, and took off heavy outerwear prior to testing. During measurement, participants maintained an upright posture with the head aligned, eyes facing forward, and trunk naturally extended. Each measurement was repeated twice, and the mean value was recorded as the final result.

Body mass index (BMI) was calculated using the standard formula: weight (kg) divided by height (m) squared. Rather than relying on lean body mass (LBM) estimates from the measurement device, the study used the academically validated, sex-specific Hume formula to calculate LBM. For males, the formula is: LBM = 0.32810 × weight (kg) + 0.33929 × height (cm) − 29.5336. Recent comparative studies have demonstrated that this formula yields high estimation accuracy and strong agreement with precise measurement results in healthy young adults, supporting its suitability for body composition assessment in this population[29]. After all measurements were completed, data were systematically organized and entered into a database for statistical analysis.

One-repetition maximum (1RM) squat test

The 1RM squat test was conducted in accordance with the safety guidelines of the American College of Sports Medicine (ACSM, 2022). Direct 1RM testing was selected over predictive equations to enhance accuracy in untrained participants, and a standardized safety protocol was maintained throughout the procedure[30]. Before testing, participants completed a standardized warm-up that included low-intensity cycling, dynamic lower-limb stretching, and light-load squat familiarization. All tests were performed using a power rack with safety pins adjusted to each participant's height. Each session was supervised by two experienced researchers to ensure proper technique and participant safety.

The parallel squat technique was consistently applied, with squat depth standardized at 90 degrees of knee flexion and verified using a bottom-touch marker. A progressive loading protocol began with a load allowing three to five repetitions, followed by 2.5 to 5.0 kg increments between attempts and 3 to 5 minutes of rest. Testing was discontinued if participants exhibited improper technique or were unable to complete the lift independently. The heaviest successful lift performed with a full range of motion was recorded as the final 1RM. All testers underwent standardized training to ensure measurement consistency.

20-meter multi-stage fitness test (20 m MFT)

Cardiorespiratory endurance was evaluated using the 20-meter multi-stage shuttle run test (Léger et al., 1988)[31]. All assessments were conducted indoors at temperatures of 22 to 25°C and relative humidity of 50% to 60%. Participants wore standardized athletic footwear to minimize environmental and equipment-related variability. Before the assessment, participants were familiarized with the testing procedures and running pace. During the test, participants ran between two 20-meter marathons in response toesponse to an audio signal, with the pace increasing incrementally until volitional two consecutive failures or failure to reach occasions. The total distance covered was recorded as the primary outcome, and maximal oxygen uptake (VO_2max) was estimated using the formula provided by Léger et al. (1988)[31].

Running-based anaerobic sprint test (RAST)

Repeated sprint ability was measured using the Running-based Anaerobic Sprint Test (RAST), which has demonstrated high test-retest reliability ($r = 0.90$)[32]. Testing took place on a standard outdoor track along a 30-meter straight sprint course with clearly marked start and finish lines. An infrared timing system (FairPlay FP-2000C, FairPlay, China) with two sensor pairs at the start and finish lines recorded sprint times. Participants began behind the starting line and sprinted 30 meters at maximal intensity upon hearing the start signal. After each sprint, participants rested for 10 seconds at the finish line before returning to the start on the next signal. This sequence was repeated for a total of six sprints.

Sprint times were used to calculate several variables. Any violation of the testing protocols resulted in the corresponding test result being deemed invalid. Power was estimated using the formula: Power = body mass (kg) × distance $(m)^2 \div$ time $(s)^3$. Maximum power was defined as the highest value among the six sprints, minimum power as the lowest, average power as the mean of all six values, and the fatigue index as (maximum power minus minimum power) divided by the total time for six sprints.

Statistical analysis

Normality of the data was evaluated using the Kolmogorov-Smirnov test, with $p > 0.05$ indicating a normal distribution. Homogeneity of variance was assessed using Levene's test, where $p > 0.05$ indicated no violation of this assumption. Descriptive statistics were reported as means and standard deviations. A significance threshold of $p < 0.05$ was applied to all statistical tests. Mixed-design analysis of variance (ANOVA) was used for both within-group and between-group comparisons to assess health-related changes in body parameters between the experimental and control groups during the training period. When significant differences were identified, post hoc comparisons were conducted using the Bonferroni test. Cohen's effect sizes (ES) were calculated to determine the magnitude of differences between groups for health-related fitness. An ES in the range [0.0, 0.2] was considered negligible, [0.2, 0.5] as small, [0.5, 0.8] as moderate, and ES > 0.8 as large. All statistical analyses were conducted using SPSS software (version 29.0.0, IBM SPSS Statistics, Armonk, NY, USA).

Results

Baseline characteristics

Table 3 presents the baseline characteristics of the three groups. At baseline, no significant differences were observed among groups for any measured variable (all SMD < 0.50), confirming the effectiveness of randomization. The SMD for body weight ranged from 0.03 to 0.16, for BMI from 0.11 to 0.32, and for lean body mass from 0.01 to 0.12. The SMD for 1RM squat ranged from 0.05 to 0.15, for 20-meter MFT distance from 0.06 to 0.11, for estimated maximal oxygen uptake (VO_2 max) from 0.06 to 0.11, for peak power from 0.15 to 0.50, for mean power from 0.04 to 0.41, and for fatigue index from 0.02 to 0.51, indicating negligible or minimal differences.

Pre-to-Post adaptations

Table 4 provides descriptive statistics for all outcome measures before and after the intervention. Significant group-by-time interactions were observed for body mass ($F = 10.800$, $p < 0.001$, $\eta p^2 = 0.340$), BMI ($F = 10.093$, $p < 0.001$, $\eta p^2 = 0.325$), lean body mass ($F = 14.019$, $p < 0.001$, $\eta p^2 = 0.400$), 1RM squat ($F = 68.857$, $p < 0.001$, $\eta p^2 = 0.766$), 20 m MFT distance ($F = 51.142$, $p < 0.001$, $\eta p^2 = 0.709$), estimated VO_2 max ($F = 50.159$, $p < 0.001$, $\eta p^2 = 0.705$), peak power ($F = 11.543$, $p < 0.001$, $\eta p^2 = 0.355$), mean power ($F = 17.076$, $p < 0.001$, $\eta p^2 = 0.448$), and fatigue index ($F = 5.456$, $p = 0.008$, $\eta p^2 = 0.206$).

Within-group analysis indicated that the SSG group demonstrated significant improvements in body mass (-2.8%; $p < 0.001$; $\eta p^2 = 0.501$), BMI (-2.8%; $p < 0.001$; $\eta p^2 = 0.540$), lean body mass (-1.9%; $p < 0.001$; $\eta p^2 = 0.562$), 1RM squat (+7.4%; $p < 0.001$; $\eta p^2 = 0.881$), 20 m MFT distance (+19.8%; $p < 0.001$; $\eta p^2 = 0.798$), estimated VO_2 max (+10.0%; $p < 0.001$; $\eta p^2 = 0.796$), peak power (+15.8%; $p < 0.001$; $\eta p^2 = 0.489$), mean power (+19.3%; $p < 0.001$; $\eta p^2 = 0.625$), and fatigue index (+19.5%; $p < 0.001$; $\eta p^2 = 0.330$).

The BSG group significantly improved body mass (-2.7%; $p < 0.001$; $\eta p^2 = 0.488$), BMI (-2.7%; $p < 0.001$; $\eta p^2 = 0.488$), lean body mass (-1.8%; $p < 0.001$; $\eta p^2 = 0.546$), 1RM squat (+6.9%; $p < 0.001$; $\eta p^2 = 0.862$), 20 m MFT distance (+20.5%; $p < 0.001$; $\eta p^2 = 0.806$), estimated VO_2 max (+10.3%; $p < 0.001$; $\eta p^2 = 0.802$), peak power (+15.6%; $p < 0.001$; $\eta p^2 = 0.474$), mean power (+14.4%; $p < 0.001$; $\eta p^2 = 0.480$), and fatigue index (+19.8%; $p < 0.001$; $\eta p^2 = 0.304$). In contrast, the CG group did not show significant changes in any measured variable (all $p > 0.05$).

Between-group analysis revealed no significant differences among the three groups in body mass, BMI, lean body mass, 1RM squat, 20-meter MFT distance, or estimated VO_2 max (all $p > 0.05$). For repeated sprint ability, both the SSG and BSG groups demonstrated significantly higher peak power (SSG vs CG: $p < 0.001$; BSG vs CG: $p < 0.001$) and mean power (SSG vs CG: $p < 0.001$; BSG vs CG: $p = 0.002$) compared to the control group. Similarly, the fatigue index was significantly higher in both intervention groups than in the control group (SSG vs CG: $p = 0.002$; BSG vs CG: $p = 0.040$). No significant differences were observed between the SSG and BSG groups for any repeated sprint measure (all $p > 0.05$).

Training load monitoring

Table 5 summarizes the significant physiological and perceptual responses observed in both training groups throughout the 8-week intervention. For mean heart rate (HRmean), significant main effects were found for group ($F = 8.760$, $p = 0.006$) and time ($F = 66.883$, $p < 0.001$), while the group-by-time interaction was not significant ($F = 0.509$, $p = 0.509$). The BSG group consistently exhibited higher mean heart rates than the SSG group, and both groups showed a concurrent decrease in mean heart rate during the intervention, indicating cardiovascular adaptation. For rating of perceived exertion (RPE), a significant group-by-time interaction was observed ($F = 18.664$, $p < 0.001$), reflecting differences in fatigue responses between exercise modalities. Post hoc analysis indicated that the BSG group reported higher RPE in week 1, whereas the SSG group reported higher perceived exertion in weeks 6 and 7. No group differences were observed from weeks 2 to 5 and in week 8. For perceived mental effort (RSME), a significant group-by-time interaction was also observed (F

= 4.250, p = 0.018), indicating different patterns of cognitive load reduction across groups, although no overall group differences were detected. In contrast, PACES scores showed no significant main effects or interactions (all p > 0.05), indicating that exercise enjoyment remained stable across groups and time points.

Discussion

This randomized controlled trial was designed to investigate the effects of an 8-week recreational basketball and soccer small-sided game (SSG) training program on body composition, muscular strength, cardiorespiratory endurance, and repeated sprint ability in untrained young adults. The results demonstrated that both the basketball and soccer groups exhibited significant improvements in body weight, BMI, 1RM squat, 20-meter multi-stage fitness test performance, and repeated sprint ability, whereas no significant changes were observed in the control group. The improvements in most outcome measures were comparable between the two intervention modalities, confirming our hypothesis that recreational basketball and soccer training confer similar health-promoting effects in untrained young populations.

Regarding body composition, both intervention groups demonstrated significant reductions in body mass and BMI. These improvements can be attributed to the intermittent high-intensity nature inherent to small-sided game training—characterized by frequent accelerations, decelerations, vertical jumps, and multidirectional changes of direction—which substantially increase total energy expenditure and excess post-exercise oxygen consumption (EPOC), thereby promoting the oxidation of subcutaneous and visceral adipose tissue[11,33]. Previous studies have shown that 12 weeks of recreational soccer training reduced fat mass by 2.7 kg, decreased body fat percentage by 3.0%, and increased lean body mass by 1.7 kg in untrained males, with effects superior to moderate-intensity continuous jogging[15]. Similar results have been observed in overweight and obese adolescents, in which 8 weeks of basketball and soccer SSG training reduced BMI and body fat percentage by approximately 9% to 10%, along with significant decreases in waist circumference and skinfold thickness[16]. Systematic reviews have confirmed that longer and more frequent recreational ball game interventions amplify these body composition benefits, with recreational soccer showing particularly large effect sizes (up to 1.72 kg of fat loss), as well as increased lower-limb capillary density and skeletal muscle remodeling[6,10,14]. Collectively, these findings support the effectiveness of recreational team sports as interventions for improving body composition in sedentary populations.

Both the SSG and BSG groups improved their 1RM squat performance by 7.4% and 6.9%, respectively. Small-sided games provide high-intensity, multi-directional load stimuli to the neuromuscular system, including repeated sprints, changes of direction, jumps, and decelerations, which enhance motor unit recruitment and intermuscular coordination, thereby increasing maximal strength output[34,35]. A 16-week training study in amateur handball players reported significant improvements in 1RM squat following SSG intervention[36]. Meta-analytical evidence has confirmed that SSG is superior to non-game-based training modalities, such as independent high-intensity interval training, in improving lower-limb power, with a moderate pooled effect size (SMD = 0.51)[37]. In well-trained basketball players, 4 weeks of 3v3 basketball SSG also resulted in increases in squat 1RM[38]. While SSG effectively enhances muscular strength, traditional resistance training should be included to maximize strength development[39].

The soccer and basketball groups improved their 20-meter multi-stage fitness test performance by 19.8% and 20.5%, respectively, with corresponding increases in estimated VO_2max of 10.0% and 10.3%. These results align with previous systematic reviews indicating that team sport interventions of 8 weeks or longer can increase VO_2 max by 2.2% to 31.3% and improve intermittent endurance by 0.1% to 79.8%[21]. Meta-analyses have shown that SSG interventions increase VO_2 max by an average of 3.51 mL/kg/min (effect size d = 1.46), with improvements exceeding those observed in sedentary controls and traditional endurance training[2]. During SSG sessions, the mean heart rate is maintained at 75% to 85% of maximum, combined with frequent sprints, changes of direction, and turning movements. These activities impose intermittent loads on the cardiorespiratory system and stimulate peripheral skeletal muscle mitochondrial biogenesis, upregulation of oxidative enzyme activity, and increased capillary density, collectively enhancing aerobic metabolic capacity[10,11,14]. Our findings further support the equivalence of different team sports in enhancing cardiorespiratory fitness. This enhancement in aerobic capacity also provides a physiological foundation for recovery during repeated sprint efforts.

Repeated sprint ability (RSA) is influenced by multiple factors, including anaerobic glycolytic capacity, lower-limb power, short-distance sprint speed, change-of-direction ability, and sport-specific skills[13,40]. Seitz et al. (2014) found that following 8 weeks of SSG training in elite rugby league players, mean sprint time and total sprint time decreased by 2.11%, and sprint decrement improved from 7.10% to 5.93%[41]. Improvements in aerobic fitness induced by SSG accelerate post-exercise phosphocreatine resynthesis and enhance lactate clearance, thereby delaying the accumulation of peripheral fatigue during repeated sprints[40]. Meta-analytical evidence has confirmed that SSG training significantly improves RSA performance, reducing total sprint time (ES = -0.41) and fatigue index (ES = -0.83), with an overall moderate effect size (ES = -0.54)[42]. However, a systematic review of youth basketball players reported inconsistent findings regarding the effects of SSG on RSA, with some studies showing significant improvements and others observing no significant effects[43]. Additionally, Dello Iacono et al. (2016) found that dedicated repeated sprint training was superior to SSG in improving 10-m sprint and lower-limb power in elite handball players[44]. Therefore, for the purpose of further optimizing repeated sprint performance, it is recommended that SSG training be combined with targeted sprint and agility drills.

In addition to the physiological adaptations, recreational small-sided basketball and soccer training significantly enhanced participants' exercise enjoyment. This finding aligns with previous research demonstrating that small-sided games elicit greater affective responses compared to traditional high-intensity interval training[45,46]. This sustained positive affective response may be attributed to the inherent recreational characteristics of team-based small-sided games, including playfulness, social interaction, and moderate competition[35,47]. In contrast, the RPE and RSME responses revealed differential patterns between the two modalities: basketball elicited higher initial perceived exertion, while soccer required greater mental effort during later training sessions, which may be attributed to the greater tactical complexity and spatial awareness required in soccer small-sided games[48]. Collectively, these findings suggest

that while both sports provide enjoyable exercise experiences, their psychological demands differ in ways that may influence individual preference and long-term adherence[49].

This study presents several limitations. First, the 8-week intervention period restricts the assessment of long-term adaptive changes and their sustainability. Future research should extend the intervention duration to determine whether these improvements persist over time. Second, dietary intake and daily unstructured physical activities were not rigorously controlled, which may have influenced body composition and physiological outcomes. Subsequent studies should incorporate objective monitoring methods, such as accelerometry and food diaries. Third, as the participants were young college students, the generalizability of these findings to middle-aged and older adults, overweight individuals, or clinical populations remains uncertain. Further research with more diverse samples is necessary to evaluate the applicability of SSG interventions across various demographic groups.

Conclusion

This randomized controlled trial found that eight weeks of recreational basketball and soccer small-sided game (SSG) training led to significant and comparable improvements in body composition, muscular strength, cardiorespiratory fitness, and repeated sprint ability among untrained young adults. High levels of exercise enjoyment were maintained throughout the intervention. The similar effectiveness of both modalities indicates that the intermittent high-intensity structure of SSG, rather than sport-specific skills, is responsible for the observed physiological adaptations. This finding supports the flexible prescription of SSG in community settings based on individual preference. From a public health perspective, SSG represents a time-efficient and engaging approach to reducing physical inactivity in sedentary young adults. Overall, both recreational basketball and soccer SSG are effective, practical, and enjoyable interventions for enhancing fitness in untrained young adults, and they serve as valuable tools for promoting active lifestyles.

Declarations

Data availability

The raw data of the present study are available from the corresponding author upon reasonable request.

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Author contributions

YL and WS conceived and designed the study, and was responsible for data collection, data analysis, and manuscript drafting. GD.Z participated in data collection and organization. YL, WS, HT.L and XJ.H participated in manuscript written and revision. All authors contributed to the content of the article and approved the submitted version.

Competing interests

The authors declare no competing interests.

Informed consent

Written informed consent was obtained from all participants.

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Tables

Table 2. Description of the 8-week recreational soccer small-sided games (SSG) and basketball small-sided games (BSG) training programs.

Week	Format	Game Structure	Total Game Time	Rest Intervals	Field Size	Frequency
1	3v3	4 × 5 min	20 min	3 × 2 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
2	4v4	4 × 5 min	20 min	3 × 2 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
3	3v3	4 × 5 min	20 min	3 × 2 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
4	4v4	4 × 5 min	20 min	3 × 2 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
5	3v3	2 × 10 min	20 min	1 × 3 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
6	4v4	2 × 10 min	20 min	1 × 3 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
7	3v3	2 × 10 min	20 min	1 × 3 min	SSG: 20×15 m BSG: Half-court	3 sessions/week
8	4v4	2 × 10 min	20 min	1 × 3 min	SSG: 20×15 m BSG: Half-court	3 sessions/week

SSG: soccer small-sided games; BSG: basketball small-sided games.

Table 3. Pre- and post-intervention values for all outcome measures across the three groups.

Variable	SSG (n=15)	BSG (n=15)	CG (n=15)	SMD (SSG vs BSG)	SMD (SSG vs CG)	SMD (BSG vs CG)
Body mass (kg)	74.1±8.1	74.4±8.4	75.3±7.4	0.03	0.16	0.12
BMI (kg/m²)	23.5±2.8	23.8±3.0	24.2±1.7	0.11	0.32	0.17
lean body mass (kg)	56.5±4.3	56.4±4.3	57.0±4.3	0.01	0.11	0.12
1RM (kg)	54.9±9.7	54.1±7.5	53.7±5.9	0.10	0.15	0.05
20 m MFT (m)	533.3±94.9	528.0±92.5	541.3±138.7	0.06	0.07	0.11
VO_2 max (ml/kg/min)	37.5±3.4	37.3±3.3	37.8±4.9	0.06	0.07	0.11
PP (W)	252.3±21.8	248.3±31.9	242.3±17.7	0.15	0.50	0.23
MP (W)	165.0±14.6	164.5±18.3	159.6±11.8	0.04	0.41	0.32
IF (W/s)	4.5±0.5	4.3±0.9	4.3±0.4	0.37	0.51	0.02

SSG: soccer small-sided games group; BSG: basketball small-sided games group; CG: control group; BMI: body mass index; 1RM: one-repetition maximum; MFT: multi-stage fitness test; VO_2 max: maximal oxygen uptake; PP: peak power; MP: mean power; IF: fatigue index. SMD: <0.10 (negligible), 0.20 (small), 0.50 (medium), and 0.80 (large). SMD: Standardized Mean Difference. Thresholds for interpreting SMD: <0.10 (negligible), 0.20 (small), 0.50 (medium), and 0.80 (large).

Table 4**. Pre- and post-intervention values for all outcome measures across the three groups.**

Variable	Group	Pre	Post	Change (%)	Within-group ηp²	Mixed repeated-measures ANOVA
Body mass (kg)	SSG	74.09±8.12	72.05±7.11*	-2.8%	0.501	time
	BSG	74.36±8.39	72.37±7.51*	-2.7%	0.488	(F= 61.093, p < 0.001, = 0.593)
	CG	75.32±7.36	75.09±7.10	-0.3%	0.012	time × group
						(F = 10.800, p < 0.001, = 0.340)
BMI (kg/m²)	SSG	23.5±2.8	22.8±2.5*	-2.8%	0.540	time
	BSG	23.8±3.0	23.2±2.7*	-2.7%	0.488	(F= 63.480, p < 0.001, = 0.602)
	CG	24.2±1.7	24.1±1.6	-0.3%	0.020	time × group
						(F = 10.093, p < 0.001, = 0.325)
lean body mass (kg)	SSG	56.5±4.3	55.4±3.9*	-1.9%	0.562	time
	BSG	56.4±4.3	55.4±4.0*	-1.8%	0.546	(F= 76.798, p < 0.001, = 0.646)
	CG	57.0±4.3	56.9±4.2	-0.2%	0.013	time × group
						(F = 14.019, p < 0.001, = 0.400)
1RM (kg)	SSG	54.9±9.7	59.0±9.3*	+7.4%	0.881	time
	BSG	54.1±7.5	57.8±7.9*	+6.9%	0.862	(F= 442.757, p < 0.001, = 0.913)
	CG	53.7±5.9	54.3±6.0	+1.1%	0.139	time × group
						(F = 68.857, p < 0.001, = 0.766)
20m MFT (m)	SSG	533.3±94.9	638.7±109.4*	+19.8%	0.798	time
	BSG	528.0±92.5	636.0±100.3*	+20.5%	0.806	(F= 238.018, p < 0.001, = 0.850)
	CG	541.3±138.7	546.7±136.4	+1.0%	0.010	time × group
						(F = 51.142, p < 0.001, = 0.709)
VO_2 max (ml/kg/min)	SSG	37.5±3.4	41.2±3.9*	+10.0%	0.796	time
	BSG	37.3±3.3	41.1±3.6*	+10.3%	0.802	(F= 234.174, p < 0.001, = 0.848)
	CG	37.8±4.9	38.0±4.9	+0.5%	0.010	time × group
						(F = 50.159, p < 0.001, = 0.705)
PP (W)	SSG	252.3±21.8	292.1±27.5*	+15.8%	0.489	time
	BSG	248.3±31.9	286.9±32.6*	+15.6%	0.474	(F= 55.040, p < 0.001, = 0.567)
	CG	242.3±17.7	244.6±21.9	+0.9%	0.003	time × group
						(F = 11.543, p < 0.001, = 0.355)
MP (W)	SSG	165.0±14.6	196.9±18.2*	+19.3%	0.625	time
	BSG	164.5±18.3	188.2±25.3*	+14.4%	0.480	(F= 74.861, p < 0.001, = 0.641)
	CG	159.6±11.8	161.1±15.2	+0.9%	0.004	time × group
						(F = 17.076, p < 0.001, = 0.448)
IF (W/s)	SSG	4.5±0.5	5.4±0.8*	+19.5%	0.330	time
	BSG	4.3±0.9	5.1±1.0*	+19.8%	0.304	(F= 28.258, p < 0.001, = 0.402)
	CG	4.3±0.4	4.3±0.5	+1.4%	0.003	time × group
						(F = 5.456, p = 0.008, = 0.206)

SSG: soccer small-sided games group (n = 15); BSG: basketball small-sided games group (n = 15); CG: control group (n = 15). BMI: body mass index; 1RM: one-repetition maximum; MFT: multi-stage fitness test; VO_2 max: maximal oxygen uptake; PP: peak power; MP: mean power; IF: fatigue index. * significant differences between the pre and the post (p < 0.05).

Table 5 .Training intensity and psychological responses across the 8-week intervention

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8	
	SSG	BSG	SSG	BSG	SSG	BSG	SSG	BSG	SSG	BSG	SSG	BSG	SSG	BSG	SSG	B
HRmean	164.2 ± 1.4	166.4 ± 1.9	162.8 ± 1.4	164.5 ± 2.4	162.1 ± 1.4	163.2 ± 2.3	161.9 ± 1.1	162.9 ± 2.1	161.7 ± 1.1	162.7 ± 2.3	161.3 ± 1.1	162.7 ± 2.0	158.9 ± 1.4	160.5 ± 2.8	158.8 ± 1.2	1 ±
RPE	6.8 ± 0.4	7.3 ± 0.4	6.7 ± 0.4	6.8 ± 0.4	6.5 ± 0.7	6.8 ± 0.4	6.6 ± 0.7	6.7 ± 0.5	6.3 ± 0.5	6.3 ± 0.2	6.3 ± 0.4	6.0 ± 0.2	6.2 ± 0.4	6.3 ± 0.4	5.8 ± 0.4	5 (
PACES	18.2 ± 0.6	18.2 ± 0.5	18.1 ± 0.5	18.0 ± 0.5	18.0 ± 0.4	18.0 ± 0.2	18.0 ± 0.4	18.0 ± 0.5	18.1 ± 0.5	18.1 ± 0.5	18.0 ± 0.4	18.0 ± 0.3	18.0 ± 0.34	18.0 ± 0.5	18.0 ± 0.4	1 ±
RSME	85.2 ± 5.7	83.2 ± 5.9	81.5 ± 5.2	79.7 ± 5.4	76.8 ± 5.6	75.1 ± 5.8	75.3 ± 5.16	73.1 ± 5.8	78.8 ± 5.6	77.1 ± 5.8	74.8 ± 5.6	73.07 ± 5.80	71.3 ± 5.2	69.1 ± 5.8	71.3 ± 5.2	6 ±

HRmean: mean session heart rate (beats·min⁻¹); RPE: Rating of Perceived Exertion; PACES: Physical Activity Enjoyment Scale; RSME: Rating Scale for Mental Effort.

Figures

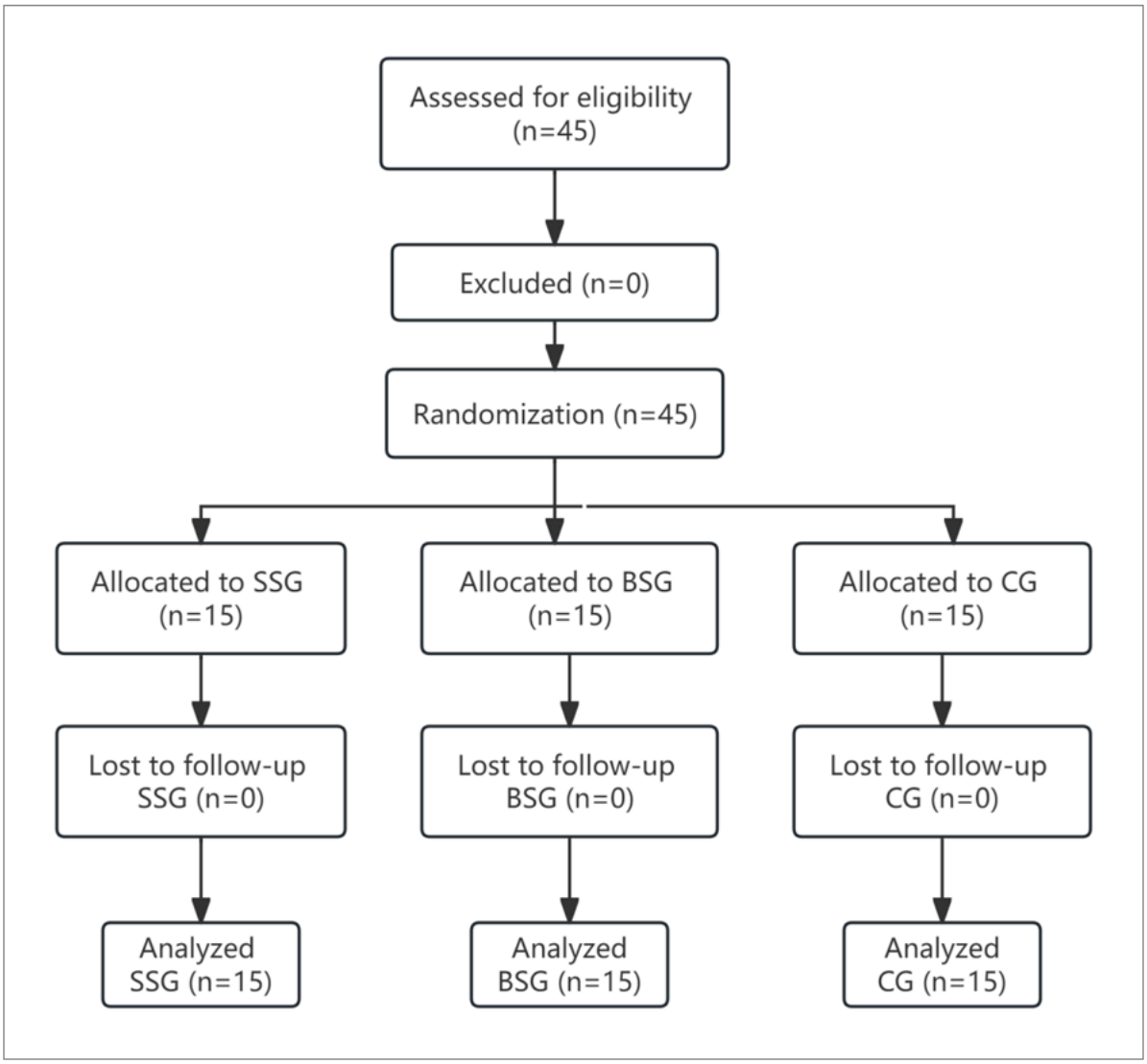


Figure 1

Flowchart. SSG: soccer small-sided games group; BSG: basketball small-sided games group; CG: control group.