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Musen Wei

Kunsan National University

Baodong Yang

Kunsan National University

Jiawei Chen

Hunan Mechanical & Electrical Polytechnic

Zhanfei Zheng

Wenzhou Medical University

Xinjie Han

xinjiehan@yeah.net

Kunsan National University

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Effects of Small-Sided Basketball Games and High-Intensity Interval Training on Body Composition, Cardiovascular Health, and Physical Performance in Sedentary Young Adults: A Randomized Controlled Trial

Musen Wei¹, Baodong Yang¹, Jiawei Chen², Zhanfei Zheng^{3,4}, Xinjie Han^{1,*}

¹ Kunsan National University, Gunsan, Jeonbuk-do, Republic of Korea

² Hunan Mechanical & Electrical Polytechnic, Changsha, Hunan, China

³ Department of Sports Science, Wenzhou Medical University, Wenzhou, Zhejiang, China

⁴ Sports Coaching College, Beijing Sport University, Beijing, China

* Corresponding author: Xinjie Han, Email: xinjiehan@yeah.net.

Abstract

This study compared an 8-week heart-rate-matched basketball small-sided-game (SSG) intervention and high-intensity interval training (HIIT) for changes in body composition, cardiovascular physiological indices and physical performance among sedentary young adults. A randomized controlled trial design was adopted. Ninety eligible sedentary young adults (age: 20.13 ± 0.75 years) were equally allocated into the SSG group, HIIT group and blank control group ($n = 30$ for each group). Both exercise groups completed 16-minute standardized training three times weekly over eight weeks, with heart-rate-matched exercise intensity maintained at 80%–85% of maximum heart-rate. After the 8-week intervention, the SSG group reduced body mass by -3.12 kg, BMI by -1.06 kg/m², systolic blood pressure (SBP) by 3.17 mmHg and resting heart rate (RHR) by 3.57 bpm. The HIIT group produced comparable improvements: body mass -2.99 kg, BMI -1.02 kg/m², SBP -2.83 mmHg, RHR

−3.47 bpm. Sprint, jump, change-of-direction and 20-m shuttle-run performance were significantly enhanced in both training groups ($p < 0.05$), while no significant within-group changes appeared in controls ($p > 0.05$). No significant inter-group differences were detected between SSG and HIIT for all measured variables ($p > 0.05$), yet both interventions yielded superior SBP and agility benefits relative to the control group ($p < 0.05$). Notably, SSG brought lower perceived exertion under identical training loads. In conclusion, 8-week basketball SSG and HIIT induce equivalent physical and cardiovascular adaptations in sedentary young adults. Participants may choose the appropriate training protocol in light of personal preference, and entertaining recreational basketball SSG is more conducive to sustained long-term exercise compliance than monotonous running HIIT.

Keywords: sedentary young adults; small-sided games; high-intensity interval training; body composition; cardiovascular fitness; physical performance

Introduction

The shift in modern lifestyles has led sedentary behavior to become a major public health issue, particularly among young people. Extended periods of inactivity contribute to adverse changes in body composition, increased visceral fat, and decreased lean body mass, alongside a heightened risk of chronic cardiovascular diseases¹. According to the World Health Organization's 2020 physical activity guidelines, adults should participate in 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity aerobic exercise per week and minimize sedentary time. Despite these recommendations, over one-quarter of adults globally fail to meet these standards¹. Key barriers to

regular physical activity among young people include limited time, lack of exercise diversity, and poor long-term adherence.

High-intensity interval training (HIIT) has grown popular due to its time efficiency and proven capacity to enhance overall physical fitness. Previous studies have demonstrated that HIIT significantly improves maximal oxygen uptake, repeated sprint ability, change-of-direction performance, and lower-limb explosive power^{2,3}. Meta-analyses have also confirmed that HIIT reduces body fat and optimizes blood pressure and heart rate reserve^{4,5}.

For example, eight weeks of HIIT improves cardiorespiratory fitness, lowers systolic blood pressure, and alleviates metabolic syndrome-related symptoms, with superior effects compared to moderate-intensity continuous training⁶. Research targeting university students has documented that nine weeks of HIIT reduces body weight and BMI, while enhancing jumping, sprinting, and agility performance⁷. Low-frequency HIIT safely improves cardiac function in sedentary older adults without inducing pathological cardiac remodeling⁸. These chronic physiological adaptations arise from repeated maximal exercise bouts that elevate cardiac output and boost skeletal muscle oxygen utilization and metabolic efficiency^{9,10}. However, traditional running-based HIIT is often perceived as monotonous and highly fatiguing, which reduces long-term adherence among untrained populations¹¹.

In contrast, recreational small-sided basketball games adopt a game-based intermittent training approach. Training intensity can be adjusted by modifying court size, player count, and game rules, which allows participants to maintain moderate-to-high physiological loads while sustaining intrinsic exercise motivation¹²⁻¹⁴. Existing research has verified that this training format consistently elicits heart rates above 80% of maximal HR, delivering physiological loads equivalent to conventional HIIT while generating lower perceived exertion and more positive affective responses^{11,15-17}. Regular recreational

basketball participation has been shown to reduce body fat percentage, improve cardiorespiratory capacity, and normalize resting cardiovascular indicators in untrained young adults¹⁸.

Beyond cardiorespiratory and metabolic adaptations, frequent jumping, sudden braking and directional shifts unique to basketball provide multi-directional mechanical stimuli that benefit bone metabolism and musculoskeletal health^{18,19}. Randomized controlled trials have illustrated that recreational team sport training produces comparable or even superior gains in aerobic capacity, explosive power and muscular strength relative to traditional exercise modes among sedentary and obese populations²⁰. Systematic reviews further confirm that small-sided basketball and soccer interventions substantially improve body composition, reduce waist circumference, and optimize cardiometabolic profiles in overweight sedentary individuals^{21,22}. Importantly, the game structure and social interaction embedded within small-sided sports boost exercise enjoyment and support sustainable long-term participation for sedentary young adults²³⁻²⁵.

Prior comparative studies have identified comparable aerobic capacity, sprint and neuromuscular improvements following SSG and HIIT interventions^{14,16,26-28}. Nevertheless, most existing research focuses on athletes or physically active populations and mainly explores soccer small-sided games. Direct head-to-head randomized controlled trials comparing basketball SSG and running HIIT specifically in sedentary young adults remain limited, especially studies covering comprehensive measurements of body composition, cardiovascular function and multi-dimensional physical performance.

Therefore, this study aimed to compare the 8-week effects of small-sided basketball games (SSG) and running-based high-intensity interval training (HIIT) on body composition, cardiovascular health, and physical performance in sedentary young adults. We hypothesized that relative to the control group,

both 8-week intervention modalities would induce significant favorable changes in all measured fitness indicators, with equivalent physiological benefits between SSG and HIIT. We further hypothesized that under matched average heart rate loads, participants in the SSG group would report lower perceived exertion, a factor conducive to better long-term exercise adherence.

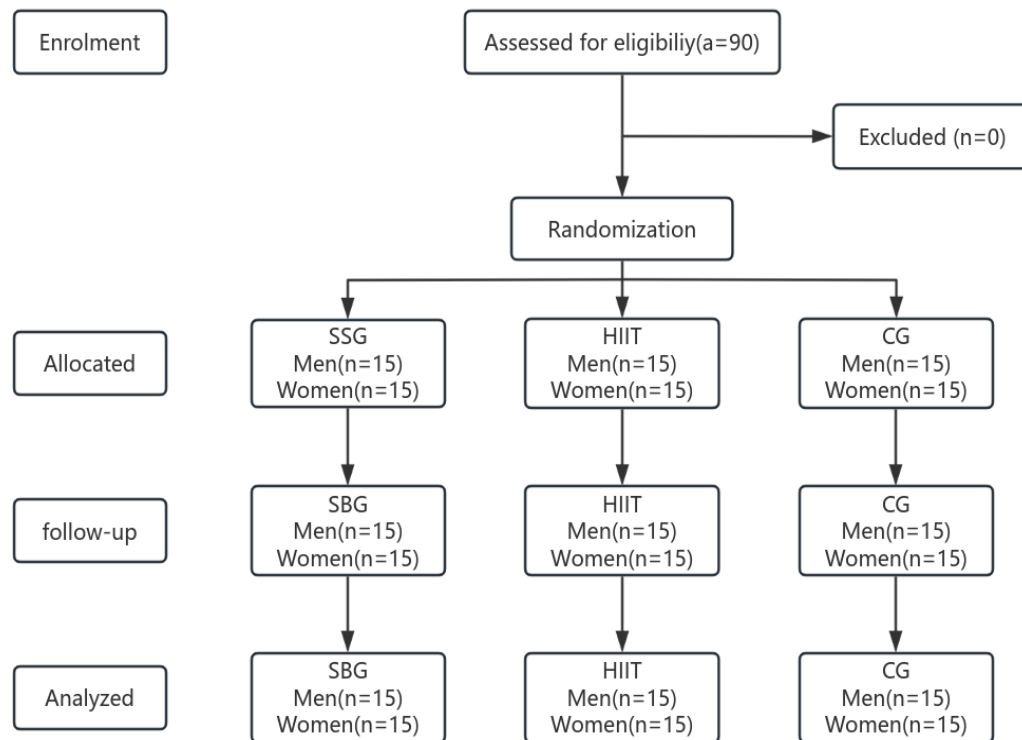


Figure 1. Flowchart. SSG: small-side games; HIIT: High-intensity interval training; CG: control group.

Materials and Methods

Study Design and Randomization

A randomized controlled trial design was utilized. Participants were allocated in a 1:1:1 ratio to a small-sided games group (SSG, n = 30), a high-intensity interval training group (HIIT, n = 30), or a control group (CG, n = 30) (Figure 1).

Randomization was conducted using the online software Research Randomizer, applying sex-stratified permuted block randomization (block sizes of 3 and 6) to ensure balanced group

allocation. An independent researcher, not involved in participant recruitment or assessment, generated and maintained the randomization sequence. Group allocation was concealed in sealed opaque envelopes and disclosed after completion of baseline testing.

Recruitment was conducted through campus advertisements and student community announcements. Inclusion criteria included: (1) absence of acute or chronic disease; (2) no contraindications to exercise or musculoskeletal injury; and (3) ability to complete all intervention sessions and assessments. Participants in the intervention group were required to maintain a training attendance rate of at least 85%.

Table 1. General descriptive parameters. SSG: small-sided games; HIIT: high-intensity interval training; CG: control group; BMI: body mass index.

	SSG (n=30)		HIIT (n=30)		CG (n=30)		Total
	Man	Woman	Man	Woman	Man	Woman	
Age	20.27±0.70	20.07±0.96	20.33±0.62	19.87±0.74	20.00±0.76	20.27±0.70	20.13±0.75
Height(m)	1.78±0.05	1.67±0.05	1.77±0.06	1.66±0.07	1.76±0.04	1.67±0.04	1.72±0.07
Weight(kg)	73.53±8.60	61.85±6.15	74.25±8.08	62.43±6.12	74.76±4.51	62.41±6.34	68.20±8.92
BMI(kg/m ²)	23.25±2.74	22.27±1.94	23.63±2.72	22.80±2.12	24.06±1.10	22.30±1.74	23.05±2.18

SSG: small-sided games; HIIT: high-intensity interval training; CG: control group; BMI: body mass index.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and received approval from the Ethics Committee of Hunan Institute of Mechanical and Electrical Technology (Approval No. 20260109; January 09, 2026). Written informed consent was obtained from all participants, who were also informed of their right to withdraw from the study at any time without penalty. This randomised controlled trial was retrospectively registered in the ISRCTN registry (ISRCTN15752118; registration date: 09 September 2026). The trial protocol is available at <https://doi.org/10.1186/ISRCTN15752118>.

Participants

The sample size was estimated a priori using G*Power software (Version 3.1). Based on an assumed effect size of $f = 0.25$, $\alpha = 0.05$, statistical power of 0.80, and a repeated-measures correlation of $r = 0.5$ for a 3×2 mixed-design ANOVA, the required sample size was calculated as 42 participants. To account for potential attrition, 90 participants were recruited.

Participants were sedentary young adults (mean age: 20.13 ± 0.75 years; height: 1.72 ± 0.07 m; body mass: 68.20 ± 8.92 kg) who engaged in less than 150 minutes per week of moderate-to-vigorous physical activity. Baseline characteristics are summarized in Table 1.

Habitual physical activity levels were assessed using the short-form International Physical Activity Questionnaire (IPAQ-SF). No significant between-group differences were observed at baseline ($p > 0.05$). Similarly, no significant changes in physical activity levels were observed in the control group before and after the intervention ($p > 0.05$).

Table 2. Description of the basketball small-sided games (SSG) and high-intensity interval training (HIIT) training programs.

Period of time	Group SSG	Group HIIT
Week 1 - Week 2	Format: 3v3	Sets: 4
	Pitch Size: 12 × 15 m	Repetitions: 4
	Coach encouragement: Yes	Work: 30s-
	Number of sets: 4	Active recovery: 30s-
	Work duration: 4 min/set	Work intensity: 80%-85% HRmax
Week 3 - Week 4	Rest between sets: 3 min (passive)	Recovery intensity: 4 km/h
	Format: 5v5	Rest between sets: 3 min (passive)
	Pitch Size: 20 × 15 m	Sets: 4
	Coach encouragement: Yes	Repetitions: 4
	Number of sets: 2	Work: 30s-
Week 5 - Week 6	Work duration: 8 min/set	Active recovery: 30s-
	Rest between sets: 5 min (passive)	Work intensity: 80%-85% HRmax
	Format: 3v3	Recovery intensity: 4 km/h
	Pitch Size: 12 × 15 m	Rest between sets: 3 min (passive)
	Coach encouragement: Yes	Sets: 4
Week 7 - Week 8	Number of sets: 4	Repetitions: 4
	Work duration: 4 min/set	Work: 40s
	Rest between sets: 3 min (passive)	Active recovery: 20s
	Format: 5v5	Work intensity: 80%-85% HRmax
	Pitch Size: 20 × 15 m	Recovery intensity: 4 km/h
	Coach encouragement: Yes	Rest between sets: 3 min (passive)
	Number of sets: 2	Sets: 4
	Work duration: 8 min/set	Repetitions: 4
	Rest between sets: 5 min (passive)	Work: 40s
		Active recovery: 20s
		Work intensity: 80%-85% HRmax
		Recovery intensity: 4 km/h
		Rest between sets: 3 min (passive)
		Sets: 4
		Repetitions: 4

Training Intervention

The intervention was conducted over eight weeks, with training sessions held three times per week (Monday, Wednesday, and Friday) at 17:30 in a group-based format. The mean environmental conditions during training were $23.1 \pm 3.4^{\circ}\text{C}$ and $53.2 \pm 4.2\%$ relative humidity. Prior to each session, participants completed a standardized 15-minute warm-up that included moderate-intensity jogging, dynamic stretching, and reactive movement drills. Training frequency, session duration, and relative intensity were standardized across all groups.

Small-Sided Games (SSG)

The SSG intervention alternated between 3v3 and 5v5 basketball formats. The 3v3 games were conducted on a 14×15 m court in four 4-minute bouts, each separated by 3 minutes of passive

recovery. The 5v5 games were conducted on a 24 × 15 m court in two 8-minute bouts, each separated by 5 minutes of passive recovery. The total exercise duration was 16 minutes for both formats. Standard basketball rules were applied, with the additional requirement that teams attempt a shot within 15 seconds of gaining ball possession to maintain exercise intensity. Coaches provided general verbal encouragement but did not offer technical or tactical instruction.

High-Intensity Interval Training (HIIT)

HIIT sessions were conducted on an outdoor synthetic running track using two interval formats: 30 seconds of sprinting with 30 seconds of active recovery, and 40 seconds of sprinting with 20 seconds of active recovery. Active recovery involved walking at 4 km·h⁻¹. Both formats included 4 sets of 4 repetitions, with each set separated by 3 minutes of passive recovery, for a total exercise duration of 16 minutes. Training intensity was individualized based on each participant's maximum heart rate (HRmax), determined using the Bruce treadmill protocol to volitional exhaustion²⁹. Participants exercised at 80–85% HRmax throughout the intervention.

Exercise Intensity and Load Monitoring

Exercise intensity was monitored using heart rate (HR) and rating of perceived exertion (RPE). Heart rate was continuously recorded at 1 Hz with a Huawei GT 4 smartwatch worn on the non-dominant wrist. Mean HR values were calculated for each training session. Previous validation studies have demonstrated strong agreement between this device and chest-worn heart rate monitors during exercise³⁰.

Perceived exertion was assessed immediately after each session using the Borg CR10 scale³¹.

Participants were permitted to consume water ad libitum during training sessions. Session HR and RPE

values were used to quantify internal training load. The combined use of these measures provides a more comprehensive assessment of overall load during exercise³².

Testing Protocol

Three certified coaches, each having received standardized training prior to the study, conducted all assessments. Testing sessions occurred at 17:00 under controlled environmental conditions (20–25°C; 50–60% relative humidity). Participants were instructed to maintain their usual diet and sleep patterns throughout the study and to abstain from strenuous exercise, alcohol, and caffeine for 24 hours before testing. Prior to formal testing, participants received standardized instructions and completed familiarization trials. The testing battery was administered over four consecutive days: (1) resting heart rate, blood pressure, height, body mass, and body mass index (BMI); (2) standing long jump, vertical jump, and 5-0-5 change-of-direction test; (3) 10-m and 30-m sprint tests; and (4) the 20-m Multistage Fitness Test (20-m MFT).

Anthropometric assessment

Height was measured with a portable stadiometer (SECA 213, Hamburg, Germany) accurate to 0.1 cm. Participants wore standard training attire and stood barefoot in an upright position. Body mass was measured using a portable digital scale (SECA 760, Hamburg, Germany) accurate to 0.1 kg. To reduce measurement error, each index was measured twice, and the mean value was used as the final result.

Blood Pressure and Resting Heart Rate

Resting blood pressure and heart rate were assessed at baseline (pre-intervention) and at week 8. All measurements were conducted at 09:00 on non-training days to minimize confounding effects from acute exercise and circadian rhythm. Participants fasted for at least 2 hours and abstained from water

for 1 hour before testing. Upon arrival at the laboratory, participants rested quietly for 15 minutes before measurement.

All measurements were conducted by the same trained researcher using a calibrated electronic blood pressure monitor (Omron HEM-7136, Kyoto, Japan), whose accuracy has been previously validated³³. An appropriately sized cuff was selected according to the participant's upper arm circumference, and the right arm was supported at heart level. Three consecutive measurements were taken at 1-minute intervals. For statistical analysis, the latter two measurements were used to enhance data reliability. Resting heart rate was assessed using the same standardized protocol. The average within-subject coefficients of variation (CV) for systolic blood pressure, diastolic blood pressure, and resting heart rate were 3.5%, 3.2%, and 3.6%, respectively.

Sprint Performance

Sprint performance over 10 m and 30 m was assessed on an artificial turf surface using a domestic electronic timing gate (FairPlay, FP-2000C) with infrared sensing technology and a precision of 0.001 s. Participants used a split-stance standing start with the dominant leg forward, maintaining a consistent starting position across all trials. Timing gates were set at hip height, with the starting position 5 m in front of the first pair of photoelectric gates. Each participant completed two trials with a 3-minute rest interval between attempts; the best performance was recorded. The average coefficient of variation for all sprint trials was 3.8%.

Standing Long Jump (SLJ)

Participants stood with feet shoulder-width apart behind the take-off line, arms relaxed at their sides, and performed a standing long jump without a run-up or stepping. After landing, participants exited the testing area through the front to avoid interfering with measurements. The FairPlay infrared long jump

tester (FP-TYD, China) was used to measure the horizontal distance, defined as the distance from the take-off line to the nearest ground contact point, recorded to the nearest 0.01 m. Each participant completed one familiarization trial followed by two official tests, with the best result recorded. The mean coefficient of variation for all standing long jump trials was 4.6%.

Vertical Jump (VJ)

Vertical jump height was measured using an iPhone 15 equipped with the "My Jump 2" application. Participants began in a deep squat position, with knees flexed to 90 degrees, feet shoulder-width apart, and hands fixed at the hips to prevent arm swing. Participants were instructed to maintain a vertical torso during the jump to minimize forward or backward movement. Each participant completed two trials, with the best performance recorded to the nearest 0.1 cm. Trials were filmed at 240 frames per second, and the "My Jump 2" application automatically analyzed flight time to calculate jump height. The validity and reliability of this method have been previously established³⁴. One familiarization attempt was completed prior to formal testing. The average coefficient of variation across all VJ trials was 4.0%.

Change-of-Direction (COD)

The 5-0-5 test was employed to assess short-sprint change-of-direction ability. The testing setup included an infrared timing gate 10 m from the starting line and a cone 5 m beyond the gate. Participants sprinted at maximum speed through the timing gate, touched the cone, and then sprinted back through the gate before decelerating. Following a standardized warm-up, each participant completed two maximal trials separated by a 2-minute rest interval, with the best performance recorded. Participants selected their preferred support leg during the turn³⁵. The average coefficient of variation across all COD trials was 4.3%.

20-m Multistage Fitness Test (20 m MFT)

Cardiorespiratory fitness was assessed using the published standard protocol³⁶. Participants ran back and forth between two lines spaced 20 m apart, with each turn synchronized to a pre-recorded audio beep. Turning within the boundary lines was permitted, and participants were not required to fully cross the end line. The test progressed in stages, with the beep frequency increasing gradually; each stage lasted approximately one minute. The test concluded when participants failed to reach the line in time on two consecutive occasions or stopped running early on two consecutive attempts. The primary outcome measure was the total distance covered.

Statistical Analyses

Normality of data was evaluated using the Shapiro–Wilk test, and homogeneity of variance was assessed with Levene’s test. Descriptive statistics are reported as mean $\pm$ standard deviation (SD). Statistical significance was defined as $p < 0.05$. A mixed-design analysis of variance (ANOVA) was conducted to assess the effects of time (pre versus post) and group on all outcome variables. When significant main or interaction effects were observed, Bonferroni-adjusted post hoc comparisons were applied. Effect sizes (ES) were calculated using Cohen’s d and classified as trivial (<0.2), small ($0.2–0.5$), moderate ($0.5–0.8$), or large (≥ 0.8). All statistical analyses were conducted using IBM SPSS Statistics (Version 29.0; IBM Corp., Armonk, NY, USA).

Results

Table 3. Comparison of baseline characteristics of participants in different groups (mean $\pm$ standard deviation)

	Measure	SSG(n=30)	HIIT(n=30)	CG(n=30)	P
	Body mass (kg)	73.53 $\pm$ 8.60	74.25 $\pm$ 8.08	74.76 $\pm$ 4.51	0.898
Man (n=45)	BMI (kg/m ²)	23.25 $\pm$ 2.74	23.63 $\pm$ 2.72	24.06 $\pm$ 1.10	0.632
	SBP (mmHg)	128.33 $\pm$ 4.72	128.40 $\pm$ 4.39	127.13 $\pm$ 2.30	0.617
	DBP (mmHg)	82.13 $\pm$ 4.70	82.87 $\pm$ 4.34	84.07 $\pm$ 3.41	0.450

	Measure	SOG(n=30)	HIIT(n=30)	CG(n=30)	P
	RHR (bpm)	70.00±4.09	70.80±3.67	69.47±3.70	0.633
	SLJ (m)	1.99±0.21	2.02±0.13	2.03±0.22	0.853
	VJ (cm)	33.33±4.91	32.62±4.18	33.75±4.69	0.796
	10-m sprint (s)	1.66±0.11	1.64±0.12	1.65±0.09	0.807
	30-m sprint (s)	4.76±0.23	4.71±0.18	4.79±0.25	0.624
	COD (s)	3.20±0.13	3.23±0.11	3.19±0.10	0.675
	20m MFT (m)	938.00±146.49	1054.67±149.37	986.67±156.51	0.117
	Body mass (kg)	61.85±6.15	62.43±6.12	62.41±6.34	0.958
	BMI (kg/m ²)	22.27±1.94	22.80±2.12	22.30±1.74	0.702
	SBP (mmHg)	128.00±3.68	127.53±4.84	129.93±3.94	0.261
	DBP (mmHg)	82.67±3.40	82.53±2.23	81.93±3.54	0.790
Woman (n=45)	RHR (bpm)	73.40±3.76	72.60±3.40	72.07±2.76	0.549
	SLJ (m)	1.40±0.14	1.40±0.15	1.39±0.13	0.989
	VJ (cm)	19.93±3.34	20.35±2.50	19.75±3.49	0.866
	10-m sprint (s)	2.07±0.18	2.02±0.12	2.06±0.14	0.511
	30-m sprint (s)	5.35±0.33	5.45±0.36	5.38±0.36	0.714
	COD (s)	3.48±0.19	3.49±0.18	3.54±0.08	0.567
	20m MFT (m)	726.67±89.34	729.33±64.53	766.67±85.41	0.324

SOG: Small-Sided Games; HIIT: High-Intensity Interval Training; CG: Control Group; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; RHR: resting heart rate; SLJ: standing long jump; VJ: vertical jump; COD: change-of-direction, 20m MFT: 20-meter Multistage Fitness Test. * significantly differences between the pre and the post ($p < 0.05$).

Table 4.....

Baseline Characteristics

Baseline characteristics are presented in Table 3. After stratification by sex, no significant between-group differences were observed for any baseline variable in either males or females (all $p > 0.05$).

Pre-to-Post Adaptations

Within-group changes are presented in Table 4. Significant main effects of time and significant time $\times$ group interactions were observed for all outcomes (all $p < 0.01$).

In the SSG group, all variables improved significantly (all $P < 0.01$): body mass (MD = -3.120 kg, 95% CI: -3.498 to -2.742); BMI (MD = -1.063 kg/m², 95% CI: -1.187 to -0.940); systolic blood pressure (MD = -3.167 mmHg, 95% CI: -3.534 to -2.799); diastolic blood pressure (MD = -1.800 mmHg, 95% CI: -2.297 to -1.303); resting heart rate (MD = -3.567 bpm, 95% CI: -4.017 to -3.116); standing long jump (MD = 0.147 m, 95% CI: 0.134 to 0.160); vertical jump (MD = 2.003 cm, 95% CI: 1.690 to 2.317); 10-m sprint (MD = -0.161 s, 95% CI: -0.179 to -0.143); 30-m sprint (MD = -0.281 s, 95% CI: -0.311 to -0.251); change-of-direction ability (MD = -0.195 s, 95% CI: -0.212 to -0.178); and 20-m MFT distance (MD = 137.667 m, 95% CI: 122.512 to 152.821).

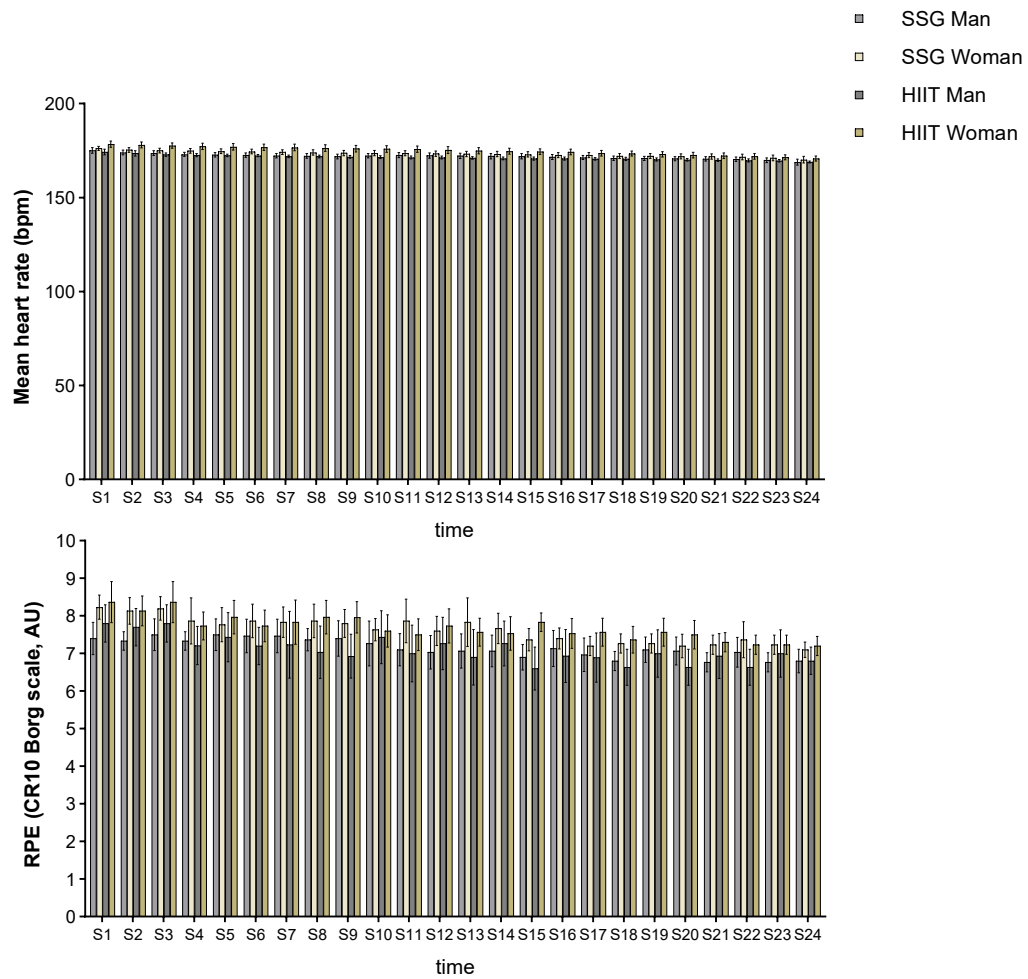
In the HIIT group, all variables also improved significantly (all $P < 0.01$): body mass (MD = -2.993 kg, 95% CI: -3.372 to -2.615); BMI (MD = -1.020 kg/m², 95% CI: -1.144 to -0.896); systolic blood pressure (MD = -2.833 mmHg, 95% CI: -3.201 to -2.466); diastolic blood pressure (MD = -1.767 mmHg, 95% CI: -2.264 to -1.269); resting heart rate (MD = -3.467 bpm, 95% CI: -3.917 to -3.016); standing long jump (MD = 0.111 m, 95% CI: 0.098 to 0.124); vertical jump (MD = 1.847 cm, 95% CI: 1.533 to 2.160); 10-m sprint (MD = -0.136 s, 95% CI: -0.154 to -0.118); 30-m sprint (MD = -0.331 s, 95% CI: -0.361 to -0.300); change-of-direction ability (MD = -0.133 s, 95% CI: -0.151 to -0.116); and 20-m MFT distance (MD = 109.200 m, 95% CI: 94.046 to 124.354).

No significant changes were observed in the CG for any outcome (all $P > 0.05$). Between-group analyses revealed that BMI was significantly lower in the SSG group than in the CG (MD = -1.330 kg/m², 95% CI: -2.642 to 0.018, $P = 0.046$). Systolic blood pressure was significantly lower in both the SSG and HIIT groups than in the CG (SSG vs. CG: MD = -3.333 mmHg, 95% CI: -5.794 to -0.872, $P = 0.004$; HIIT vs. CG: MD = -3.200 mmHg, 95% CI: -5.661 to -0.739, $P = 0.006$). Resting heart rate

was significantly lower in the SSG group than in the CG (MD = -2.267 bpm, 95% CI: -4.477 to -0.056, $P = 0.043$).

Both the SSG and HIIT groups exhibited significantly shorter 10-m sprint times than the CG (SSG vs. CG: MD = -0.151 s, 95% CI: -0.288 to -0.014, $P = 0.025$; HIIT vs. CG: MD = -0.160 s, 95% CI: -0.297 to -0.023, $P = 0.016$). Similarly, 30-m sprint times were significantly shorter in the SSG and HIIT groups than in the CG (SSG vs. CG: MD = -0.285 s, 95% CI: -0.542 to -0.027, $P = 0.025$; HIIT vs. CG: MD = -0.309 s, 95% CI: -0.566 to -0.051, $P = 0.013$). Change-of-direction time was significantly lower in both the SSG and HIIT groups than in the CG (SSG vs. CG: MD = -0.207 s, 95% CI: -0.331 to -0.084, $P < 0.01$; HIIT vs. CG: MD = -0.130 s, 95% CI: -0.254 to -0.006, $P = 0.036$). No significant differences were observed between the SSG and HIIT groups for any variable (all $P > 0.05$).

Figure 2. Descriptive statistics (mean and standard deviation) of mean heart rate and perceived exertion levels among volunteers in the SSG and HIIT groups throughout the experimental sessions



Training load monitoring

Figure 2 presents the descriptive statistics for mean heart rate (HR) and rating of perceived exertion (RPE) during the intervention period in the small-sided games (SSG) and high-intensity interval training (HIIT) groups.

For mean HR, values were 171 ± 1 bpm in males and 173 ± 1 bpm in females in the SSG group, compared with 172 ± 1 bpm and 175 ± 2 bpm, respectively, in the HIIT group. Statistical analysis revealed a significant main effect of time ($p < 0.001$) and a significant time $\times$ sex interaction effect ($p < 0.01$). Mean HR decreased progressively throughout the intervention in both groups. Although HR

values were slightly higher in the HIIT group, the between-group differences were small ($0.87\text{--}2.07$ bpm), indicating comparable cardiovascular training loads between interventions.

For RPE, scores were 7.2 ± 0.3 in males and 7.6 ± 0.4 in females in the SSG group, and 7.5 ± 0.3 and 7.8 ± 0.3 , respectively, in the HIIT group. A significant main effect of time ($p < 0.001$) and a significant time $\times$ sex interaction effect ($p = 0.041$) were observed. RPE decreased over time in both groups, whereas the HIIT group demonstrated significantly higher RPE values during the mid-to-late stages of the intervention. These findings suggest that SSG elicited lower perceived exertion despite similar cardiovascular loads.

Discussion

This study investigated the effects of an 8-week small-sided basketball game (SSG) intervention and high-intensity interval training (HIIT) on physiological indicators and physical performance in sedentary young adults. Compared with the control group, both interventions significantly improved body mass, BMI, blood pressure, resting heart rate, sprint performance, jump performance, change-of-direction ability, and aerobic capacity. No significant between-group differences were observed, suggesting that SSG and HIIT produce comparable benefits in sedentary young adults. These findings support the use of either modality as an effective time-efficient exercise strategy for improving health-related fitness in this population.

Effects of SSG and HIIT on Body Composition

Regarding body composition, both the SSG and HIIT groups exhibited significant reductions in body weight and BMI, and no statistically significant differences were detected between the two intervention groups. The weight loss observed in the SSG group is primarily attributed to the intermittent, multidirectional loading inherent in basketball activities, such as repeated acceleration, deceleration,

vertical jumping, and lateral movement. These movements engage large muscle groups, thereby increasing total energy expenditure. Additionally, the high proportion of eccentric contractions during these activities contributes to sustained fat oxidation during and after exercise ^{37,38}. One study reported that recreational basketball reduced body fat percentage by 9.5% and waist circumference by 4.7% in sedentary obese adults, findings consistent with the present results ³⁹.

In contrast, HIIT rapidly depletes muscle glycogen through short bursts of high-intensity sprints and significantly elevates excess post-exercise oxygen consumption (EPOC), thereby extending the window for post-exercise fat oxidation ^{40,41}. Similar outcomes have been observed in sedentary young women, with eight weeks of HIIT resulting in a significant $3.0 \pm 3.1\%$ reduction in body weight and an $8.2 \pm 6.0\%$ decrease in body fat percentage, while lean body mass remained stable ¹⁹. Systematic reviews confirm that both training modalities deliver equivalent fat-loss effects: recreational team sports produce a moderate fat-loss effect size of -0.43, and HIIT demonstrates a comparable standardized mean difference (SMD = -0.40) in body fat reduction ^{40,42}. These data further prove that neither intervention holds absolute superiority in fat loss. Moreover, neither exercise intervention led to compensatory increases in sedentary behavior, thereby maintaining a sustained net energy deficit and stable fat consumption throughout the training cycle ⁴³.

Effects of SSG and HIIT on Cardiovascular Health

At the cardiovascular health, both interventions significantly improved blood pressure and resting heart rate, consistent with previous research^{44,45}. In small-sided games, repeated acceleration, deceleration, and multidirectional jumping generate oscillatory vascular shear stress, which upregulates endothelial nitric oxide synthase (eNOS) expression, enhances arterial compliance, and reduces peripheral vascular resistance⁴⁶. One study found that eight weeks of recreational football and basketball training reduced

systolic blood pressure by 2.6% and 5.4%, diastolic blood pressure by 4.7% and 5.4%, and resting heart rate by 5.4%, respectively³⁹.

In contrast, HIIT improves vagal tone and baroreflex sensitivity through repeated cycles of muscle ischemia and reperfusion, while downregulating the renin-angiotensin-aldosterone system, resulting in long-term reductions in peripheral vascular resistance and central aortic pressure^{47,48}. Another study reported that HIIT significantly reduced systolic blood pressure by 5.1 mmHg and diastolic blood pressure by 2.3 mmHg in sedentary individuals⁴⁹. Systematic reviews further confirm the comparable cardiovascular benefits of the two training forms: recreational team sports reduce systolic blood pressure by 3.9% to 8.3%²¹, while HIIT produces standardized mean differences of -0.35 and -0.38 for systolic and diastolic blood pressure, alongside obvious declines in resting heart rate⁴⁰. These adaptive changes enhance stroke volume and cardiac efficiency, lower resting cardiac load, reduce visceral fat accumulation, and ultimately drive persistent improvements in blood pressure and resting heart rate^{8,39,44}.

Effects of SSG and HIIT on Physical Performance

Both small-sided games (SSG) and high-intensity interval training (HIIT) greatly improve sprinting, jumping, changing direction, and aerobic fitness, with similar levels of improvement. These findings align with earlier studies^{28,44,50}.

Small-sided games (SSG) offer similar physical challenges through frequent speeding up, slowing down, jumping, and changing direction^{18,22,27,51}. Studies show that eight weeks of basketball SSG can boost aerobic fitness by 19.6%, vertical jump by 33.9%, and standing long jump by 5.8% in inactive people²⁰. Another study with inactive obese people found that sixteen weeks of football SSG improved the 20-meter shuttle run by 36.4%, increased maximum oxygen use by 14.23%, and raised vertical

jump by 46.71%, with stronger effects in women³⁸. A review also shows that casual team sports can increase maximum oxygen use by 6.5% to 31.0% and Yo-Yo intermittent test results by 8.1% to 79.0%²¹.

The benefits of HIIT mainly come from repeated fast straight sprints, which increase heart output, improve how muscles use oxygen, and better coordinate muscle and nerve activity^{52,53}. Studies show that eight weeks of HIIT can improve sprint times over 10–30 meters, countermovement jump (CMJ), and squat jump (SJ) scores, increase YoYo IR1 test distance by 44.3%, raise maximum oxygen use by 9.2%, and cut T-drill time by 9.8%⁵³. Another study found that HIIT improved agility by 2.18%, sprint speed by 2.00% to 2.76%, and vertical jump by 8.65%⁷. A review also shows that HIIT is much better than moderate training at improving maximum oxygen use⁵⁴.

The main reason both methods improve aerobic fitness similarly is that they have similar training intensity. Basketball SSG causes an average heart rate over 85% of the maximum, with peaks between 90% and 95%, matching the intensity of HIIT^{15,55}. The 3v3 and 5v5 game formats used in this study provide enough high-intensity effort to cause heart and lung changes like those seen with HIIT^{11,13}.

Although the overall effects are similar, each training type has its own strengths: SSG improves agility and changing direction through movements in many directions, while HIIT focuses on heart and lung fitness and repeated sprints in a straight line. Arslan et al. (2022) showed that SSG leads to better T-drill results ($d=0.91$ vs 0.32), while HIIT gives bigger gains in 30 m sprint and repeated sprint ability²⁶. Likewise, SSG causes a bigger drop in zigzag change-of-direction time (-3.6% vs -2.6%), while HIIT brings stronger improvements in YYIRTL-1 and repeated sprint performance¹⁶. Importantly, SSG can lower feelings of tiredness and make exercise more enjoyable, which matches the findings of this study.

Several limitations should be acknowledged. First, the intervention duration was relatively short, and longer-term studies are needed to determine whether the observed adaptive changes can be maintained. Second, dietary intake and daily physical activity were not strictly controlled during the intervention, which may have influenced the results. Third, the sample consisted solely of sedentary young adults, limiting the generalizability of the findings to other age groups or clinical populations. Future research should examine the long-term effects of SSG and HIIT in diverse populations and explore additional physiological, psychological, and adherence-related outcomes.

Conclusion

This study found that both small-sided basketball games (SSG) and high-intensity interval training (HIIT) significantly improved body composition, cardiovascular health, and physical performance in sedentary young adults, while the control group exhibited minimal changes. No significant differences emerged between SSG and HIIT, indicating that both training modalities yield comparable physiological and performance adaptations. These results indicate that SSG and HIIT are effective and time-efficient strategies for enhancing health-related fitness in sedentary populations. Notably, recreational basketball-based SSG may offer additional motivational and social benefits that support long-term exercise adherence. Incorporating recreational team sports into physical activity interventions may therefore represent a practical strategy for increasing exercise participation among sedentary young adults.

Trial registration

ISRCTN15752118. Registered on 09 September 2026. Retrospectively registered.

Declarations

Abbreviations

SSG: small-sided games

HIIT: high-intensity interval training

CG: control group

BMI: body mass index

SBP: systolic blood pressure

DBP: diastolic blood pressure

RHR: resting heart rate

SLJ: standing long jump

VJ: vertical jump

COD: change-of-direction

20m MFT: 20-meter Multistage Fitness Test

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and received approval from the Ethics Committee of Hunan Institute of Mechanical and Electrical Technology (Approval No. 20260109; January 09, 2026). Written informed consent was obtained from all participants prior to enrollment. This randomized controlled trial was reported in accordance with the CONSORT guidelines.

Consent for publication

Not applicable

Availability of data and materials

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

Competing Interests

The authors declare no competing interests.

Funding

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Authors' contributions

WM.S and XJ.H conceived and designed the study, and were responsible for data collection, data analysis, and manuscript drafting. JW.C and BD.Y participated in data collection and organization.

WM.S, ZF.Z, JW.C and XJ.H participated in manuscript writing and revision. All authors contributed to the content of the article and approved the submitted version.

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Table 4. Descriptive statistics (mean $\pm$ standard deviation) and inferential statistics for the within- and between-group comparisons for the overall participants.

Indicators and Groups		Pre(Mean $\pm$ SD)	Post(Mean $\pm$ SD)	Change (95% CI)	η_p^2	Between-group differences at Post (adjusted means)	Cohen's d(95%CI)
Body mass(kg)	SSG	67.69 $\pm$ 9.45	64.57 $\pm$ 8.96*	-3.120 (-3.498, -2.742)	0.755	S vs H: -0.780 (-6.230, 4.670)	-0.089 (-0.595, 0.418)
	HIIT	68.34 $\pm$ 9.25	65.35 $\pm$ 8.55*	-2.993 (-3.372, -2.615)	0.740	S vs C: -3.620 (-9.070, 1.830)	-0.416 (-0.926, 0.097)
	CG	68.59 $\pm$ 8.28	68.19 $\pm$ 8.42	-0.400 (-0.778, -0.022)	0.048	H vs C: -2.840 (-8.290, 2.610)	-0.335(-0.843,0.176)
BMI (kg/m²)	SSG	22.76 $\pm$ 2.38	21.69 $\pm$ 2.27*	-1.063 (-1.187, -0.940)	0.770	S vs H: -0.503 (-1.815, 0.808)	-0.225 (-0.732, 0.283)
	HIIT	23.22 $\pm$ 2.43	22.20 $\pm$ 2.19*	-1.020 (-1.144, -0.896)	0.755	S vs C: -1.330 (-2.642, -0.018) *	-0.658 (-1.175, -0.135)
	CG	23.18 $\pm$ 1.69	23.02 $\pm$ 1.74	-0.157 (-0.280, -0.033)	0.068	H vs C: -0.827 (-2.138, 0.485)	-0.418(-0.928, 0.096)
SBP (mmHg)	SSG	128.17 $\pm$ 4.16	125.00 $\pm$ 4.14*	-3.167 (-3.534, -2.799)	0.771	S vs H: -0.133 (-2.594, 2.328)	-0.032 (-0.538, 0.474)
	HIIT	127.97 $\pm$ 4.56	125.13 $\pm$ 4.09*	-2.833 (-3.201, -2.466)	0.730	S vs C: -3.333 (-5.794, -0.872) *	-0.876 (-1.403, -0.342)
	CG	128.53 $\pm$ 3.47	128.33 $\pm$ 3.45	-0.200 (-0.560, 0.160)	0.013	H vs C: -3.200 (-5.661, -0.739) *	0.846 (-1.371, -0.314)
DBP (mmHg)	SSG	82.40 $\pm$ 4.04	80.60 $\pm$ 3.86*	-1.800 (-2.297, -1.303)	0.418	S vs H: 0.333 (-2.563, 1.896)	-0.095 (-0.601, 0.412)
	HIIT	82.70 $\pm$ 3.40	80.93 $\pm$ 3.15*	-1.767 (-2.264, -1.269)	0.409	S vs C: -1.967 (-4.142, 0.209)	-0.547 (-1.061, -0.029)
	CG	83.00 $\pm$ 3.58	82.57 $\pm$ 3.31	-0.433 (-0.886, 0.020)	0.040	H vs C: -1.633 (-3.809, 0.542)	-0.506 (-1.018, 0.011)
RHR (pbm)	SSG	71.70 $\pm$ 4.23	68.13 $\pm$ 4.24*	-3.567 (-4.017, -3.116)	0.735	S vs H: -0.100 (-2.310, 2.110)	-0.027 (-0.533, 0.479)
	HIIT	71.70 $\pm$ 3.59	68.23 $\pm$ 3.03*	-3.467 (-3.917, -3.016)	0.723	S vs C: -2.267 (-4.477, -0.056) *	-0.609 (-1.124, -0.088)
	CG	70.77 $\pm$ 3.47	70.40 $\pm$ 3.13	-0.367 (-0.823, 0.090)	0.028	H vs C: -2.167 (-4.377, 0.044)	-0.705 (-1.224, -0.180)
SLJ (m)	SSG	1.69 $\pm$ 0.35	1.84 $\pm$ 0.38*	0.147 (0.134, 0.160)	0.831	S vs H: 0.022 (-0.109, 0.235)	0.060 (-0.447, 0.565)
	HIIT	1.71 $\pm$ 0.35	1.82 $\pm$ 0.35*	0.111 (0.098, 0.124)	0.737	S vs C: 0.122 (-0.109, 0.353)	0.326 (-0.185, 0.834)
	CG	1.71 $\pm$ 0.37	1.72 $\pm$ 0.37	0.009 (-0.005, 0.023)	0.019	H vs C: -0.100 (-0.131, 0.332)	0.277 (-0.233, 0.784)
VJ (cm)	SSG	26.63 $\pm$ 7.97	28.63 $\pm$ 8.53*	2.003 (1.690, 2.317)	0.637	S vs H: 0.303 (-4.784, 5.390)	0.037 (-0.469, 0.543)
	HIIT	26.48 $\pm$ 7.10	28.33 $\pm$ 7.64*	1.847 (1.533, 2.160)	0.598	S vs C: 1.663 (-3.424, 6.750)	0.201 (-0.307, 0.707)
	CG	26.75 $\pm$ 8.20	26.97 $\pm$ 8.01	0.223 (-0.099, 0.546)	0.021	H vs C: 1.360 (-3.727, 6.447)	0.174 (-0.334, 0.680)
10-m sprint (s)	SSG	1.86 $\pm$ 0.25	1.70 $\pm$ 0.22*	-0.161 (-0.179, -0.143)	0.775	S vs H: 0.009 (-0.128, 0.146)	0.078 (-0.428, 0.584)
	HIIT	1.83 $\pm$ 0.23	1.69 $\pm$ 0.19*	-0.136 (-0.154, -0.118)	0.710	S vs C: -0.151 (-0.288, -0.014) *	-0.658 (-1.175, -0.135)

30-m sprint (s)	CG	1.86±0.24	1.85±0.24	-0.004 (-0.022, 0.014)	0.002	H vs C: -0.160 (-0.297, -0.023) *	-0.777 (-1.299, -0.249)
	SSG	5.06±0.41	4.78±0.38*	-0.281 (-0.311, -0.251)	0.797	S vs H: 0.024 (-0.233, 0.281)	0.060 (-0.446, 0.566)
	HIIT	5.09±0.47	4.75±0.43*	-0.331 (-0.361, -0.300)	0.844	S vs C: -0.285 (-0.542, -0.027) *	-0.722 (-1.242, -0.196)
COD (s)	CG	5.09±0.43	5.06±0.41	-0.26 (-0.057, 0.004)	0.032	H vs C: -0.309 (-0.566, -0.051) *	-0.734 (-1.254, -0.208)
	SSG	3.34±0.22	3.15±0.20*	-0.195 (-0.212, -0.178)	0.864	S vs H: -0.077 (-0.201, 0.046)	-0.396 (-0.906, 0.117)
	HIIT	3.36±0.20	3.23±0.19*	-0.133 (-0.151, -0.116)	0.748	S vs C: -0.207 (-0.331, -0.084) *	-1.047 (-1.583, -0.502)
20m MFT (m)	CG	3.37±0.20	3.36±0.20	-0.012 (-0.029, 0.004)	0.025	H vs C: -0.130 (-0.254, -0.006) *	-0.667 (-1.185, -0.144)
	SSG	832.33±160.51	970.00±167.23*	137.667 (122.512, 152.821)	0.789	S vs H: -31.200 (-151.229, 88.829)	-0.154 (-0.660, 0.353)
	HIIT	892.00±200.39	1001.20±232.21*	109.200 (94.046, 124.354)	0.702	S vs C: 86.000 (-34.029, 206.029)	0.519 (0.002, 1.032)
	CG	876.67±166.93	884.00±164.04	7.333 (-7.821, 22.488)	0.011	H vs C: 117.200 (-2.829, 237.229)	0.583 (0.064, 1.098)

SSG: Small-Sided Games; HIIT: High-Intensity Interval Training; CG: Control Group; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; RHR: resting heart rate; SLJ: standing long jump; VJ: vertical jump; COD: change-of-direction, 20m MFT: 20-meter Multistage Fitness Test. * significantly differences between the pre and the post ($p < 0.05$).