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Research article

Comparing The Effects of Small-Sided and Medium-Sided Soccer Games on Physical Fitness Adaptations in Untrained Men: A Randomized Controlled Study

Xinjie Han [1], Lu Li [1], Jiawei Chen [2], Weiqiang Xu [1], Robert Trybulski [3,4] and Filipe Manuel Clemente [1,5,6] ✉

[1] Gdansk University of Physical Education and Sport, Gdańsk, Poland; [2] Hunan Mechanical & Electrical Polytechnic, Hunan, Changsha, China; [3] Medical Department Wojciech Korfanty, Upper Silesian Academy, Katowice, Poland; [4] Provita Żory Medical Center, Żory, Poland; [5] Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, Viana do Castelo, Portugal; [6] Sport Physical Activity and Health Research & Innovation Center, Viana do Castelo, Portugal

Abstract

Smaller formats of sided games (SSG), such as 1v1 to 4v4, are often reported to be more physically and physiologically demanding than medium-sided games (e.g., 6v6 to 8v8). However, there is a lack of experimental research examining the effects of such stimuli on physical fitness adaptations in untrained men. This study aimed to compare the effects of small-sided games (SSG) and medium-sided games (MSG) on various physical fitness parameters (e.g., outcome 1; outcome 2) in untrained men after an 8-week intervention period. A randomized controlled design was used, comparing two experimental groups with a control group that maintained a sedentary lifestyle, which was confirmed through questionnaires. Sixty men (mean age: 18.8 ± 0.74 years) volunteered for the study. The experimental groups underwent a training intervention three times per week for eight weeks. Participants in the SSG group played games ranging from 1v1 to 3v3, while those in the MSG group engaged in games from 6v6 to 8v8. Before and after the intervention, all participants completed a series of fitness assessments, including the standing long jump (SLJ), vertical jump (VJ), 10- and 30-meter sprints, change of direction (COD), and a 20-meter multi-stage fitness test (MFT). Results revealed that after eight weeks, the SSG group demonstrated significant improvements over the control group in SLJ ($p < 0.01$; ES = 0.642), VJ ($p < 0.01$; ES = 0.511), 10-meter sprint ($p < 0.01$; ES = 0.62), 30-meter sprint ($p < 0.01$; ES = 0.41), COD ($p < 0.01$; ES = 0.435), and 20-meter MFT ($p < 0.01$; ES = 0.64). Similarly, the MSG group showed significant gains compared to the control group in SLJ ($p < 0.01$; ES = 0.541), VJ ($p < 0.01$; ES = 0.439), 10-meter sprint ($p < 0.01$; ES = 0.451), 30-meter sprint ($p < 0.01$; ES = 0.25), COD ($p < 0.01$; ES = 0.523), and 20-meter MFT ($p < 0.01$; ES = 0.693). In conclusion, this study shows that both SSG and MSG are equally effective in enhancing physical fitness parameters in untrained men, despite slight variations in intensity.

Key words: Football, conditioned games, physical exercise, health, aerobic exercise.

Introduction

Physical inactivity has become a growing issue in modern society, with many individuals leading sedentary lifestyles due to work, technology, and other factors (Biddle et al., 2017; Clemente et al., 2022; Xu et al., 2024a). This lack of physical activity is closely linked to low physical fitness, which in turn contributes to a range of health problems, including obesity, cardiovascular disease, and diabetes (Hammami et al., 2016a; Milanović et al., 2015b; Randers et al., 2021). Despite the known benefits of exercise, motivation to engage in traditional forms of physical activity often remains low, as many people find structured exercise routines, such as going to the gym or running, to be tedious or unappealing (Trajkovic et al., 2020). This lack of engagement highlights the need for alternative, enjoyable forms of physical activity (Castagna et al., 2018; Clemente et al., 2022; Hammami et al., 2016a). Recreational games, like soccer, provide an effective solution, offering a fun and social way to stay active, which can increase motivation and improve fitness (Hammami et al., 2016a; 2016b; 2018; Krustrup et al., 2009; Li et al., 2023). By making exercise feel less like a chore and more like a pleasurable activity, recreational games can help individuals overcome the barriers of motivation and foster long-term participation in physical activity (Castagna et al., 2018; Krustrup et al., 2010b; Krustrup et al., 2009).

Due to the higher levels of engagement promoted by team sports, recreational soccer presents an appealing community-based solution for untrained populations. It enhances both initial participation and long-term adherence to physical activity among children, adolescents, and adults (Milanović et al., 2015a). Furthermore, recreational soccer has excellent potential for preventing and treating non-communicable diseases (Flotum et al., 2016; Randers et al., 2024). A recent literature review suggests that regular participation in recreational soccer can enhance physical fitness and health in untrained individuals. It has been shown to lower blood pressure, improve cardiovascular function, and positively impact metabolic indicators in both healthy individuals and clinical populations (Castillo-Bellot et al., 2019; Krustrup et al., 2010a; 2009). It can also reduce body mass, fat percentage, and blood sugar levels in obese populations (Cvetković et al., 2018; Krustrup and Bangsbo, 2015; Vasconcellos et al., 2015).

Recreational soccer is typically played using sided games, which are modified, smaller versions of the formal game. These sided games allow for the management of task objectives and other conditions, ultimately enabling the adjustment of the physiological and physical stimuli experienced by the participants (Hill-Haas et al., 2011a; Impellizzeri et al., 2006; Köklü and Alemdaroğlu, 2016; Köklü et al., 2020; Milanović et al., 2015b). Among other factors,

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the most common adjustments in sided games are related to the format of play (i.e., the number of players involved) and the dimensions of the pitch. For example, smaller game formats (SSG: such as 1v1 and 3v3) are typically highly demanding, with average heart rates exceeding 85% of the maximum heart rate during exercise. These formats often result in higher lactate concentrations compared to medium-sided games (MSF: such as 6v6 or 8v8), surpassing four mmol/L, which creates optimal conditions for the development of aerobic power (Hill-Haas et al., 2011a). On the other hand, larger formats of play, typically conducted on bigger pitches, provide opportunities for neuromuscular stimulation due to the increased demands of high-speed running and prolonged running (Castillo et al., 2021). These acute stimuli may contribute to different adaptations when implemented regularly. However, despite this potential, research on untrained populations remains limited. In fact, most studies involving sided games (such as recreational soccer training formats) focus on comparisons with other training modalities, such as high-intensity interval training (Cvetković et al., 2018). As a result, there is a gap in understanding how different sided-game formats may lead to varying levels of adaptations in physical fitness, as observed in players in previous studies (Wang et al., 2024).

Therefore, it is essential to explore further how different formats of sided-games can be utilized as a training strategy to improve the physical fitness of untrained young men, while also considering how variations in these formats may influence adaptation tendencies. Based on that, this study aimed to compare the effects of SSG and MSG on physical fitness adaptations in untrained men following a period of intervention. We hypothesize that SSG will have a greater impact on aerobic development due to the higher physiological load compared to MSG. Additionally, we expect that MSG may play a more significant role in enhancing muscle power and sprinting, as the larger playing area allows for more frequent sprints and increased mechanical effort during running.

Methods

This study followed the ethical standards outlined in the Helsinki Declaration for medical research involving human subjects. The participants were informed about the study design and provided written informed consent, which explicitly stated that they were free to withdraw from the study at any time without any penalty. This study has received ethical approval from the Hunan Mechanical & Electrical Polytechnic (Approval number is 2024009; May 22, 2024).

Study design

This study employs a parallel controlled study design. In this study, participants were randomly assigned to three groups: the SSG group (n = 20), the MSG group (n = 20), and the control group No-Small Sided Games (NSG) (n = 20), without exposure to sided games. Randomization was performed prior to group allocation using a 1:1 ratio. This process involved the use of opaque envelopes, which were randomly assigned to participants. The randomization was carried out by a researcher, who assigned each player to an envelope corresponding to a specific group. The concealment of the allocation process is ensured through rigorous randomization and sealed envelopes, enhancing the reliability and impartiality of processing allocation in the experiment. The recruitment approach included extending verbal invitations and reference letters to college students, distributing informational letters in common areas of the college, and promoting the study through social media. This study was blinded only for the evaluators, who were unaware of the players' group assignments, while neither the players nor the training intervention administrators were blinded. The inclusion criteria comprised individuals with no prior exposure to recreational soccer, absence of any acute or chronic illnesses, absence of any injuries or ongoing treatments, adherence to strict discipline, and participants needed to maintain a compliance rate of more than 85% in the case of experimental SSG and MSG groups while actively engaging at all assessment time points. Prior written informed consent was obtained from all participants, who were thoroughly briefed on all procedures and potential risks involved. Participants in the experimental group followed prescribed exercises, while those in the control group did not engage in any specific training regimen. The study lasted for 10 weeks, during which participants in the SSG and MSG groups trained three times a week and were evaluated for training one week before the training began (week 1) and one week after the training ended (week 10). To ensure fluency and enjoyment in mini-games, all participants underwent an initial training phase consisting of eight sessions lasting 45 minutes, each focusing on technical skills such as passing and dribbling.

Table 1. General descriptive parameters.

	SSG (n = 20)	MSG (n = 20)	NSG (n = 20)
Age (years)	18.9 ± 0.89	18.8 ± 0.77	18.8 ± 0.59
Height (m)	1.74 ± 0.05	1.71 ± 0.05	1.74 ± 0.07
body mass (kg)	67.9 ± 14.15	69.6 ± 17.51	67.34 ± 14.85

SSG: small-sided games; MDS: medium-sided games; NSG: control group

Participants

The sample size was estimated using the G*Power software (version 3.1), with a bias effect size of 0.2, a power of 0.8, a significance level (p-value) of 0.05, and a correlation of 0.5, considering three groups and two measurements. According to the calculation results, the required sample size is 54. During the actual recruitment process, a total of 60 individuals (Figure 1) who were interested in participating in the experiment were included in the study: Age 18.8 ± 0.74 years old; Height 1.73 ± 0.74m; Body mass was 68.3 ± 15.33kg. The average weekly activity time of these subjects was no more than 90 minutes, and they carried out moderate to low-intensity exercise, which met the requirements of this experiment. After random grouping, the characteristics of each group are shown in Table 1.

The participants' daily physical activity was assessed using a short version of the International Physical Activity Questionnaire, administered at two time points: before and after the intervention. The results showed similar levels of physical activity across the groups at baseline. Furthermore, no significant changes were observed within the control group before and after the intervention.

According to these reports, both the SSG and MSG groups had compliance rates of over 95% throughout the trial, as evidenced by their attendance records. Attendance was recorded at each session using a registration form. In addition, no participants dropped out of the study, and no additional specific encouragement or engagement strategies were implemented beyond an inherent commitment to training.

Training intervention

The training intervention occurred three days a week, on Monday, Wednesday, and Friday. The team training sessions started at 5:30 p.m. During the training period, the average temperature was 25.1 ± 3.4°C, and the relative humidity was 54.2 ± 4.2%. After a standard warm-up protocol consisting of 5 min of self-paced moderate running, five minutes of lower-limb dynamic stretching, and five minutes of reactive strength exercises focused on the lower limbs, the players were separated into groups and started the training protocol Table 2. A more detailed description of the training program is presented in Table 2. There was no difference in the training volume, intensity, and frequency, which represented an important factor when comparing the effects of these three groups.

In our study, both heart rate (HR) and rating of perceived exertion (RPE) were used as indicators to evaluate physical effort during sided games. HR was selected because it offers a direct, objective measure of the physiological response to exercise, reflecting the intensity of cardiovascular demand. However, HR can be influenced by factors such as hydration, fatigue, or environmental conditions, which may not fully capture the subjective experience of exertion. In contrast, RPE provides a subjective assessment of effort based on the individual's perception of workload, accounting for factors like locomotor demands, such as mechanical work or total distance covered. By using both HR and RPE, we were able to gain a more comprehensive understanding of the physical effort exerted by the players.

The Borg CR10 scale was used during the training period to assess the participants' exercise intensity, and personal scores were recorded approximately 20 minutes after each training session. The Borg CR10 is an effective tool for evaluating perceived fatigue and can differentiate tasks of different difficulty levels in complexity, height, and resistance. It is suitable for all genders and has been widely used to evaluate cardiorespiratory and muscular strength performance in exercise (Ritchie, 2012). In addition, heart rate can provide a more accurate reflection of exercise intensity. Furthermore, the heart rate was monitored at 1 Hz using a telemetry-based heart rate monitor (Polar RS400, Kempele, Finland). The players were permitted to consume water during intervals to ensure adequate hydration under all sports conditions considered in this study (Póvoas et al., 2019).

Measurement procedures

The assessment is conducted by two professional trainers, with the test commencing at 5 pm daily under an average temperature ranging from 20° to 25°. Players are required to maintain a regular dietary intake throughout the evaluation period. The players were briefed on the testing procedures and divided into three groups. On the first day of testing, measurements included body mass, height, body mass index (BMI), and a stage fitness test covering a distance of over 20 meters. The following day, subjects underwent straight sprints of 10 and 30 meters, twice each, selecting their best result while taking a two-minute break between tests. The third day involved completing standing long jump and change-of-direction tests using the 5-0-5 method. For standing long jumps, two consecutive measurements were taken without any rest in between, whereas for change-of-direction tests, there was a two-minute break between individual measurements.

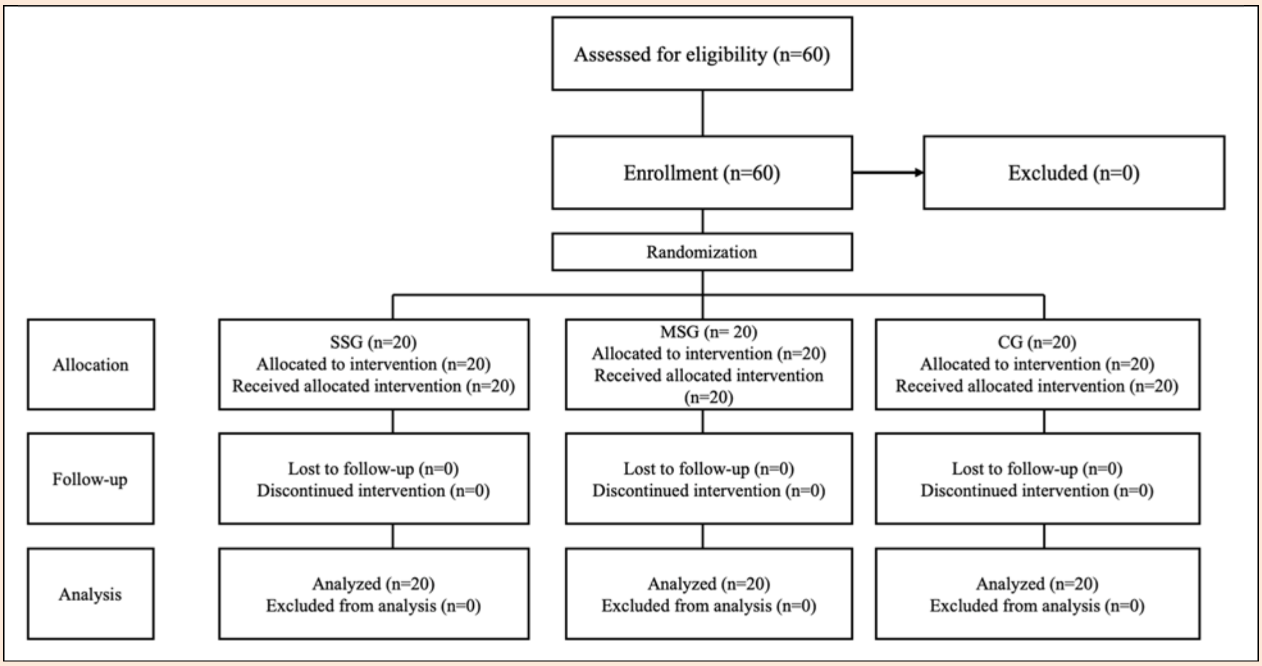

Figure 1. Flowchart. SSG: small-sided games; MSG: medium-sided games.

Table 2. Description of the training programmes for soccer.

	SSG session 1	MSG session 1
Week 1 and Week 3	SSG format:1v1 Pitch Size:10x15m Coach encouragement: Yes No goals(ball-handling) No offside Sets:2 Repetitions:2 Work: 1m 30 s Rest: 1m 30 s Rest between groups:4min	MSG format 6v6 Pitch Size:30x30m Coach encouragement: Yes Small goals:3×2m No offside and the goalkeeper Sets:2 Repetitions:2 Work: 6min Rest: 5min Rest between groups:5min
Week 2 and Week 4	SSG format：3v3 Pitch Size:18 x 25m Coach encouragement: Yes No goals(ball-handling) No offside Sets:2 Repetitions:2 Work: 3 min Rest: 3 min Rest between groups：4min	MSG format 8v8 Pitch Size:40x40m Coach encouragement: Yes Small goals:3×2m No offside and the goalkeeper Sets:2 Repetitions:2 Work: 8min Rest: 5min Rest between groups:6min
Week 5 and Week 7	SSG format：1v1 Pitch Size:10 x 15m Coach encouragement: Yes No goals(ball-handling) No offside Sets:2 Repetitions:2 Work: 2 min Rest: 2 min Rest between groups：4min	MSG format 6v6 Pitch Size:30x30m Coach encouragement: Yes Small goals:3×2m No offside and the goalkeeper Sets:2 Repetitions:2 Work: 6min Rest: 5min Rest between groups:4min
Week 6 and Week 8	SSG format：3v3 Pitch Size:18 x 25m Coach encouragement: Yes No goals(ball-handling) No offside Sets:2 Repetitions:2 Work: 3 min Rest: 3 min Rest between groups：4min	MSG format 8v8 Pitch Size:40x40m Coach encouragement: Yes Small goals:3×2m No offside and the goalkeeper Sets:2 Repetitions:2 Work: 8min Rest: 5min Rest between groups:4min

SSG: small-sided games; MSG: medium sided-games.

On the final assessment day, subjects performed vertical long jump tests consecutively, twice, and recorded their highest scores achieved. The measurements were conducted following a standardized warm-up protocol, which included five minutes of moderate-intensity self-regulated running, five minutes of dynamic and static stretching explicitly targeting the lower limbs, and reactivity strengthening exercises for the lower limbs.

Anthropometric assessment

Athletes' height was measured with precision using a portable altimeter (SECA 213, Hamburg, Germany), which was accurate to 0.1 cm while they wore standardized training attire and stood barefoot in front of a wall. Body mass assessment was conducted using a portable scale (SECA 760, Hamburg, Germany), which was accurate to 0.1 kg. To minimize potential errors, all measurements were performed twice.

Sprinting ability

The electronic timing gates (FairPlay, FP-2000C, China) manufactured in China were used to evaluate the performance of standing start 10-meter and 30-meter sprints on artificial turf. These timing gates utilized infrared technology to measure the segmented speed of athletes with an accuracy of up to 0.001 seconds. The participants started in a split position, with the preferred leg in front. The position and preferred leg were kept the same across the trials. The timing gates were adjusted to each participant's hip height. The starting position was 30 cm before the first pair of photocells. Each participant underwent two tests with a 3-minute rest period between tests, and the best test result for each distance was recorded. Athletes had to stand both front and back and could choose which foot went in front based on personal preference. The average coefficient of variation within players across sprint ability trials was 3.2%.

Standing long jump (SLJ)

In the standing long jump test (SLJ), the subject stood on the starting line, with their feet shoulder-width apart, and performed the long jump action with their hands naturally hanging down. They were not allowed to take a step or perform a continuous jump when jumping from the same spot, and they had to exit from the front after completing the jump. The measured data represented the distance from the starting line to the nearest landing point, which was determined using FairPlay's infrared long jump measuring instrument (FP-TYD, FairPlay, China). All participants could practice once and then perform two official trials, with their best scores recorded. The average coefficient of variation within players across SLJ trials was 3.8%.

Vertical jump (VJ)

The vertical jump (VJ) measures the height of a jump by using the "My Jump 2" app on an iPhone 15. Participants were guided to start in a deep squat position with knees bent at 90°. They maintained a standing position with their feet shoulder-width apart, hands on their hips, and were instructed to keep their hands stable throughout the process to complete a jump to reach maximum height. To reduce the influence of trunk movement on the test results, the trunk had to remain as vertical as possible during the vertical take-off. Each participant performed two tests, and the highest score was recorded to the nearest 0.01 centimeters. The My Jump2 software positioned the phone at an appropriate angle to capture the foot and ground position during the test. The "slow motion" camera mode (fps 240) was used to capture the participant during the test, and the data were analyzed using My Jump 2, which has previously been shown to be both valid and reliable (Haynes et al., 2019). All participants could practice once and then perform two official trials, with their best scores recorded. The average coefficient of variation within players across VJ trials was 4.2%.

Change of direction (COD)

The 5-0-5 test (COD) is often used to evaluate an athlete's agility and change-of-direction ability during short, fast sprints. The test involved setting up two cones at the starting line, 10 and 15 meters apart. An infrared timing device was placed parallel to the 10-meter line. The athlete prepared and then sprinted at maximum acceleration to pass the timing device at the 10-meter line and reach the second cone, where they had to touch the cone with one foot. They then performed a reverse sprint and passed the timing device again, gradually slowing down. The athlete was advised to warm up thoroughly before the test and perform two maximum-effort tests. There was a two-minute rest between each test, and the best result was recorded. Additionally, in the COD task, the athlete could choose which leg to use for the change of direction movement (Nayıroğlu et al., 2022). The average coefficient of variation within players across COD trials was 2.9%.

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

Participants underwent a multi-stage adaptive test (MFT) according to the established protocol outlined in prior publications (Cooper et al., 2005). This test was used to assess individuals' cardiorespiratory fitness and muscular endurance levels. Participants had to run back and forth between two lines spaced 20 meters apart, synchronizing each return with a pre-recorded audio track that played beeping signals at regular intervals. Contestants could turn around and continue running within the designated boundaries but were prohibited from turning after crossing the boundary. During the test, participants gradually progressed through different levels, each lasting over one minute, with the beeping sound accelerating as they reached new levels.

The test ended in two scenarios: when the participant failed to reach the line twice in a row, and the beep sounded, or when the participant stopped running without waiting for the beep twice in a row. The primary outcome was determined by recording the total distance each participant ran during the shuttle run test.

Statistical analysis

The normality of the data was assessed using the Kolmogorov-Smirnov test, with $p > 0.05$ indicating a normal distribution, and homogeneity of variance was verified using Levene's test, where $p > 0.05$ suggested no violation of this assumption. Descriptive statistics were presented as means and standard deviations, and a significance level of $p < 0.05$ was set for all tests. A mixed-design analysis of variance (ANOVA) was conducted for both within- and between-group comparisons to evaluate health-related changes in body parameters between the experimental and control groups during the training period. If significant differences were detected, post hoc comparisons were performed using the Bonferroni test. To assess the magnitude of differences between groups for health-related fitness, Cohen's effect sizes (ES) were calculated. An ES of [0.0, 0.2] was considered negligible, [0.2, 0.5] as a small effect, [0.5, 0.8] as a moderate effect, and an ES > 0.8 as a large effect. All statistical analyses were performed using SPSS software (version 29.0.0, IBM SPSS Statistics, Armonk, NY, USA).

Results

Baseline assessments

No baseline differences were observed between groups for body mass ($F = 0.056$, $p = 0.945$; $\eta^2_p = 0.002$), body mass index ($F = 0.383$, $p = 0.683$; $\eta^2_p = 0.013$), standing long jump ($F = 0.218$, $p = 0.805$; $\eta^2_p = 0.008$), vertical jump test ($F = 0.651$, $p = 0.525$; $\eta^2_p = 0.022$), 10-meter sprint test ($F = 1.125$, $p = 0.332$; $\eta^2_p = 0.038$), 30-meter sprint test ($F = 0.053$, $p = 0.948$; $\eta^2_p = 0.002$), change of direction ($F = 0.394$, $p = 0.676$; $\eta^2_p = 0.014$), and multistage fitness test ($F = 0.059$, $p = 0.943$; $\eta^2_p = 0.002$).

Pre-to-post-training variations

Table 3 presents the descriptive statistics for the experimental and control groups both before and after the intervention. Significant interactions between time and group were observed for body mass ($F = 56$, $p < 0.001$; $\eta^2_p = 0.663$), body mass index ($F = 63.57$, $p < 0.001$; $\eta^2_p = 0.69$), standing long jump ($F = 17.24$, $p < 0.001$; $\eta^2_p = 0.377$), vertical jump ($F = 13.94$, $p < 0.001$; $\eta^2_p = 0.328$), 10-meter sprint test ($F = 17.47$, $p < 0.001$; $\eta^2_p = 0.38$), 30-meter sprint

Table 3. **Health-related physical fitness components for soccer and control group before an 8-week training intervention.**

		SSG (n = 20)	MSG (n = 20)	NSG (n = 20)	Mixed-begin ANCOVA
Body mass (kg)	Pre	67.9 ± 14.2	69.6 ± 17.5	67.3 ± 14.9	time × group (F = 56; p <0.001; = 0.663)
	Post	64.6 ± 13.8[a]	66.1 ± 16.5[b]	66.9 ± 14.2	
	Post-pre (%D)	-4.9%	-5.1%	-0.7%	
BMI (kg/m^2)	Pre	22.3 ± 4.6	23.6 ± 5	22.1 ± 4.3	time × group (F = 63.57; p <0.001; = 0.69)
	Post	21.2 ± 4.5[a]	22.4 ± 4.8[b]	22 ± 4.1	
	Post-pre (%D)	-4.9%	-5.1%	-0.5%	
SLJ (m)	Pre	2.21 ± 0.23	2.18 ± 0.2	2.17 ± 0.22	time × group (F = 17.24; p <0.001； =0.377)
	Post	2.29 ± 0.21[a]	2.24 ± 0.19[b]	2.18 ± 0.2	
	Post-pre (%D)	3.7%	3.1%	0.8%	
VJ (cm)	Pre	35.33 ± 4.83	35.8 ± 6.09	34.79 ± 4.66	time × group (F = 13.94; p <0.001; = 0.328)
	Post	37.42 ± 5.19[a]	37.61 ± 6.5[b]	35.0 ± 4.64	
	Post-pre (%D)	5.9%	5%	0.6%	
10 m sprint test (sec)	Pre	1.43 ± 0.08	1.38 ± 0.09	1.39 ± 0.08	time × group (F = 17.47; p <0.001; = 0.38)
	Post	1.32 ± 0.08[a]	1.31 ± 0.08[b]	1.37 ± 0.06	
	Post-pre (%D)	-7.6%	-5.4%	-1.1%	
30 m sprint test (sec)	Pre	4.34 ± 0.27	4.3 ± 0.33	4.21 ± 0.22	time × group (F = 10.7;p <0.001; = 0.375)
	Post	4.14 ± 0.23[a]	4.16 ± 0.29[b]	4.21 ± 0.21	
	Post-pre (%D)	-4.7%	-3%	-0.4%	
COD time(sec)	Pre	2.48 ± 0.21	2.49 ± 0.15	2.46 ± 0.17	time × group (F = 17.07; p <0.001; = 0.382)
	Post	2.36 ± 0.15[a]	2.35 ± 0.11[b]	2.45 ± 0.18	
	Post-pre (%D)	-4.4%	-5.6%	-0.1%	
20 m MFT (m)	Pre	1123 ± 275.09	1131 ± 188.9	1179 ± 243.18	time × group (F =32.68; p <0.001; = 0.556)
	Post	1256 ± 260.73[a]	1281 ± 188.39[b]	1184.5 ± 214.98	
	Post-pre (%D)	11.8%	13.6%	0.5%	

ES: effect size; BMI: body mass index SCG: small side game; MSG: middle side game; NSG: no soccer control group; SLJ: standing long jump; VJ: vertical jump; COD: change-of-direction MFT: multistage fitness test; a: significant difference between small side game and control group ($p < 0.05$); b: significant difference between middle side game and control group ($p < 0.05$).

test ($F = 10.7$, $p < 0.001$; $\eta^2_p = 0.375$), change of direction ($F = 17.07$, $p < 0.001$; $\eta^2_p = 0.382$), and the multistage fitness test ($F = 35.68$, $p < 0.001$; $\eta^2_p = 0.556$). Intra-group analysis revealed that after 8 weeks of intervention, the SSG group showed significant improvements in body mass (-4.9%; $p < 0.001$), body mass index (-4.9%; $p < 0.001$), standing long jump (3.7%; $p < 0.001$), vertical jump (5.9%; $p < 0.001$), 10-meter sprint test (-7.6%; $p < 0.001$), 30-meter sprint test (-4.7%; $p < 0.001$), change of direction (-4.4%; $p < 0.001$), and the multistage running test (11.8%; $p < 0.001$).

The MSG group showed significant improvements in body mass (-5.1%; $p < 0.001$), body mass index (-5.1%; $p < 0.001$), standing long jump (3.1%; $p < 0.001$), vertical jump (5%; $p < 0.001$), 10-meter sprint test (-5.4%; $p < 0.001$), 30-meter sprint test (-3.0%; $p < 0.001$), change of direction (-5.6%; $p < 0.001$), and the multistage fitness test (13.6%; $p < 0.001$).

The NSG group showed a significant improvement in body mass index (-0.5%; $p = 0.014$) and standing long jump (-0.8%; $p = 0.035$). However, no significant differences were observed in body mass (-0.7%; $p = 0.053$), vertical jump (0.6%; $p = 0.43$), 10-meter sprint test (-1.1%; $p = 0.16$), 30-meter sprint test (-0.4%; $p = 0.948$), change of direction (-0.1%; $p = 0.842$), or multistage fitness test (0.5%; $p = 0.699$).

The group comparisons revealed that, in terms of body mass, both the SSG group ($p < 0.01$, $\eta^2_p = 0.787$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.805$) performed significantly better than the NSG group ($p = 0.053$, $\eta^2_p = 0.064$). Similarly, for body mass index, both the SSG group ($p < 0.01$, $\eta^2_p = 0.81$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.836$) showed significantly greater improvements than the NSG group ($p = 0.014$, $\eta^2_p = 0.102$). However, there was no significant difference between the SSG and MSG groups ($p > 0.05$).

In the standing long jump test, both the SSG group ($p < 0.01$, $\eta^2_p = 0.642$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.541$) demonstrated significantly better performance than the NSG group ($p = 0.035$, $\eta^2_p = 0.076$). Similarly, in the vertical jump test, both the SSG group ($p < 0.01$, $\eta^2_p = 0.511$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.439$) outperformed the NSG group ($p = 0.43$, $\eta^2_p = 0.01$). However, no significant differences were found between the SSG and MSG groups ($p > 0.05$).

In the 10-meter sprint, both the SSG group ($p < 0.01$, $\eta^2_p = 0.62$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.451$) demonstrated significantly better performance than the NSG group ($p = 0.16$, $\eta^2_p = 0.034$). Similarly, in the 30-meter sprint, the SSG group ($p < 0.01$, $\eta^2_p = 0.41$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.25$) outperformed the NSG group ($p = 0.948$, $\eta^2_p = 0.0$). However, no significant difference was found between the SSG and MSG groups ($p > 0.05$).

In the change of direction test, both the SSG group ($p < 0.01$, $\eta^2_p = 0.435$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.523$) performed significantly better than the NSG group ($p = 0.84$, $\eta^2_p = 0.001$). Similarly, in the multistage fitness test, the SSG group ($p < 0.01$, $\eta^2_p = 0.64$) and the MSG group ($p < 0.01$, $\eta^2_p = 0.693$) also outperformed the NSG group ($p = 0.679$, $\eta^2_p = 0.003$). No significant difference was observed between the SSG and MSG groups ($p > 0.05$).

Training load monitoring

Figure 2 presents the descriptive statistics for the average heart rate and perceived exercise intensity of participants in the SSG and MSG groups throughout the experiment.

The average heart rate in the SSG and MSG groups was 167.3 ± 3.4 bpm and 165.7 ± 2.7 bpm, respectively. Interestingly, among all participants in the SCG and BCG, the mean heart rate was 171.1 ± 1.7 bpm during the first eight sessions. It then decreased to 166.3 ± 1.5 bpm during the next eight sessions in the second group, and further dropped to 163.2 ± 1.2 bpm during the final eight sessions.

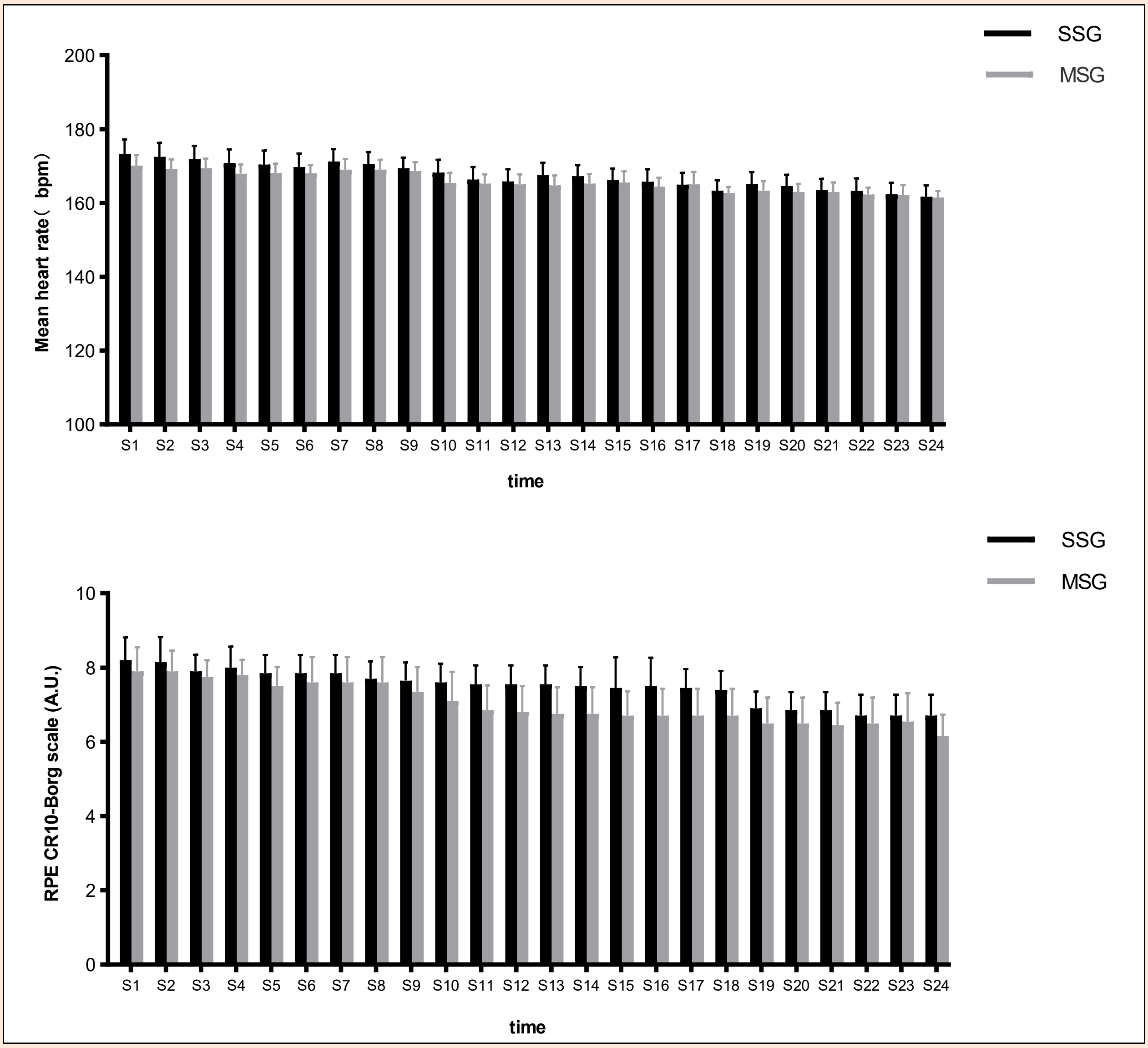

Figure 2. Descriptive statistics (mean and standard deviation) of mean heart rate and perceived exertion levels among volunteers in the SSG and MSG groups throughout the experimental sessions. SSG: small-sided games; MSG: medium-sided games; RPE: rating of perceived exertion.

Discussion

This study aimed to investigate the effects of SSG and MSG soccer training on the physical health of untrained adult males. The results demonstrated that during the 8-week intervention period, the SSG and MSG groups exhibited significant improvements in all physical performance measures, including sprint ability, standing long jump, vertical jump, change of direction, and aerobic endurance, compared to the NSG. Notably, the SSG group showed a more pronounced improvement in sprinting ability. In contrast, the MSG group exhibited a more favourable enhancement in aerobic endurance, although the difference between the two groups was not statistically significant. These findings suggest that participation in recreational soccer can effectively enhance the physical fitness of untrained men and significantly improve their athletic performance.

In both healthy untrained individuals and clinical populations, the positive effects of sided games on aerobic capacity are frequently assessed using measures such as endurance performance or VO_2 max (Zouhal et al., 2020). Our study showed that SSG and MSG significantly improved endurance following the intervention by 11.8% and 13.6%, respectively. These findings align with previous reports indicating that sided games and running have comparable effects on VO_2 max (Krustrup et al., 2010b). Additionally, Hammami et al. found that sided games produced significantly superior results on the Yo-Yo intermittent endurance test compared to running training alone (Hammami et al., 2016b).

Moreover, similar improvements in aerobic capacity have been observed in other populations, including sedentary women and older adults, further supporting the effectiveness of small-sided soccer training across different age groups and fitness levels (Bangsbo et al., 2010; Imperlini et al., 2020). The dynamic and intense nature of sided games demands higher oxygen consumption to meet the increased metabolic needs during gameplay. As a result, the heart is required to work harder to maintain an adequate cardiac output. This constant cardiovascular demand promotes adaptations in the heart and vascular system, ultimately improving overall aerobic fitness (Aslan et al., 2019; Edgett et al., 2013).

In our study, mean heart rates were higher in the SSG group compared to the MSG group, with both formats resulting in heart rates exceeding 80% of participants' maximum heart rate (HRmax). While previous studies have suggested differences in acute responses, such as Randers et al., who found that 3v3 games led to higher heart rates compared to 5v5 and 7v7 games on a field size of 80 m2, thereby increasing exercise intensity (Randers et al., 2014), and Aslan's study, which reported that a smaller number of participants, regardless of field size, corresponded to increased cardiovascular demands for each individual (Aslan, 2013), it is interesting to note that both SSG and MSG formats generated similar levels of intensity. This suggests that despite the differences in game format, both types of exercise appear to have a comparable impact on aerobic performance adaptation in untrained populations.

Regardless of age or gender, regular exposure to these high-intensity activities stimulates beneficial adaptations within the cardiovascular system, leading to enhanced heart function and improved oxygen delivery to muscle tissues. Over time, these physiological changes result in more efficient oxygen utilization during physical activity, contributing to better endurance and aerobic performance (Flotum et al., 2016; Krustrup et al., 2009; Li et al., 2023).

Additionally, the study found that the SSG group was perceived to have a higher intensity than the MSG group. This finding aligns with the results of a previous study, which found that the average workload of athletes, expressed in terms of heart rate and heart rate reserve percentage, is higher in five-a-side games than in seven-a-side games (Aslan, 2013). Similarly, other studies have demonstrated that in small-sided competitions, a reduction in players results in athletes accelerating, decelerating, and performing individual technical movements more frequently. This increased physical demand leads to higher energy expenditure and enhances metabolic function (Castellano et al., 2013; Gaudino et al., 2014).

The soccer training program also significantly improved health-related fitness, including vertical jumping, sprinting, and change of direction (Hill-Haas et al., 2011b). Given the growing emphasis on physical fitness as a critical health indicator, it is essential to incorporate fitness testing into health monitoring systems and provide effective training strategies for untrained populations to enhance their physical performance. Both SSG and MSG resulted in positive gains in vertical and horizontal jump performance, with no substantial differences between the two formats, consistent with the findings of a recent meta-analysis (Zouhal et al., 2020).

The frequent explosive movements involved in both SSGs and MSGs, such as accelerations, sprinting, jumping, and rapid changes of direction, likely provide an effective stimulus for neuromuscular adaptations in untrained populations, including increased motor unit recruitment and improved coordination of fast-twitch muscle fibers. Additionally, the eccentric-like nature of these games, driven by regular decelerations and re-accelerations, likely enhances the stretch-shortening cycle, optimizing the efficiency of muscle contractions during vertical and long jumps (Xu et al., 2024b).

The study found that both small- and medium-sized soccer games had a significant positive impact on sprint performance. This finding aligns with two previous studies, in which untrained adult men reduced their 30-meter sprint times by 0.11 seconds and 0.15 seconds, respectively, following small-field soccer training (Krustrup et al., 2010b; Randers et al., 2010). Additionally, sedentary teens who participated in an eight-week small-sided soccer training program demonstrated a 4.1% improvement in their 20-meter dash test scores (Hammami et al., 2016b). The improvement in sprinting performance in both cases can be attributed to the high-intensity, explosive nature of small- and medium-sided games, which involve frequent accelerations, decelerations, and rapid changes of direction. These activities likely benefit both neuromuscular adaptations and running mechanics, contributing to enhanced speed and overall sprint performance (Xu et al., 2024b).

The ability to change direction quickly during sprints is essential for success in both team-based and individual athletic disciplines (Bujalance-Moreno et al., 2019). Research has shown that a six-week SSG-based training program can enhance performance in key parameters such as COD, RSA, and overall sprinting capabilities in soccer players (Nygaard Falch et al., 2019). Furthermore, meta-analyses have suggested that SSG is more effective than linear HIIT in developing COD capacity (Bujalance-Moreno et al., 2019). In addition to improving muscle strength and endurance, sided games also enhance athletes' rhythm, coordination, and body control during both the starting phase and the entire sprint process. This is achieved while maintaining stable and efficient speeds, which are crucial for high-performance sprinting (Sauls and Dabbs, 2017).

Several limitations of this study must be addressed. First, the sample was limited to male participants aged 20, excluding female adults. This gender limitation reduces the generalizability of the findings to a broader population. Additionally, the intervention period lasted only eight weeks, which may have constrained the ability to observe more substantial long-term improvements in participants' aerobic capacity, sprinting, and jumping abilities.

A second limitation is the lack of full control over the exercise intensity in the control group, which hinders a comprehensive comparison of the intensity experienced by both the experimental and control groups. Furthermore, the study focused solely on aspects of body composition when assessing health-related physical components, leaving it unclear whether the observed improvements were also influenced by changes in muscle mass or neural adaptations (Holmes and Racette, 2021).

Future research should explore how recreational team sports affect cardiovascular responses, enhance enjoyment, and increase physical activity intensity over time. Additionally, comparisons with other types of interventions would help evaluate the subjective effort levels of participants and offer a broader perspective on the effectiveness of various training modalities.

As practical implications, the findings of this study suggest that SSG and MSG can be highly beneficial for a diverse range of populations, from untrained individuals to those with specific health conditions. Both SSG and MSG formats enhanced physical fitness in areas such as aerobic performance, sprinting ability, and muscular power, making these training methods applicable to people at varying fitness levels. For individuals already in good physical condition, sided games could serve as a high-intensity interval training alternative to further improve cardiovascular and neuromuscular performance. However, further research is needed to identify any potential plateaus. In populations with clinical conditions or those who are older, such training offers a safer, yet effective, way to improve heart function, endurance, and overall fitness due to the modifiable intensity of the sessions. However, careful planning of the training intervention is crucial, with preventive measures such as proper warm-up routines emphasized to prepare participants for the high-intensity demands of the game. Additionally, managing exposure to the frequent accelerations and decelerations is important to reduce the potential risk of injury. Future training programs could benefit from continuous monitoring of individual responses to exercise, along with the inclusion of personalized recovery strategies, ensuring both the safety and long-term sustainability of small-sided games as a training modality.

Conclusion

Through comparative analysis, this study found that both SSG and MSG soccer games significantly enhanced the physical fitness of untrained men. Specifically, both formats led to significant improvements in cardiorespiratory fitness, muscle power, and running speed. However, the effects on physical fitness were similar between SSG and MSG, suggesting that the number of participants -whether small or slightly larger- does not significantly impact the overall fitness improvements in untrained male athletes. Additionally, the intense nature and frequent accelerations and decelerations in sided games likely contributed to the observed improvements in speed and muscle power. Therefore, both SSG and MSG can be effective for untrained populations, with combinations of the two potentially offering additional benefits in specific contexts. Participating in recreational soccer not only enhances individual physical fitness but also encourages the development of a healthier lifestyle. Moreover, it provides an enjoyable and accessible way for teenagers who do not regularly engage in training to experience the benefits of team competition.

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Key points

- Both small-sided (SSG) and medium-sided (MSG) soccer games significantly improved physical fitness in untrained men, including aerobic capacity, muscle strength, sprint performance, and agility.
- Both SSG and MSG are effective, practical options for improving physical fitness, providing flexibility for coaches and athletes to choose based on preference or availability.

AUTHOR BIOGRAPHY

Xiejie HAN
Employment
Gdansk University of Physical Education and Sport, Gdańsk, Poland
Degree
Master
Research interests
Soccer training; Adolescent physical development
E-mail: xinjie.han@awf.gda.pl

Lu LI
Employment
Gdansk University of Physical Education and Sport, Gdańsk, Poland
Degree
Master
Research interests
Basketball training, sport intervention and Physical education
E-mail: lu. li@awf.gda.pl

Jiawei CHEN
Employment
Hunan Mechanical and Electrical Vocational Technical College.
Degree
Doctoral candidate
Research interests
Adolescent health behaviour.
E-mail: karlhun@163.com

Weiqiang XU
Employment
Gdansk University of Physical Education and Sport, Gdańsk, Poland
Degree
Master
Research interests
Soccer training; sports psychology
E-mail: weiqiang.xu@outlook.com

Robert TRYBULSKI
Employment
Medical Department Wojciech Korfanty, Upper Silesian Academy, Katowice, Poland
Degree
Ph.D.
Research interests
Physiotherapy, sports, regenerative techniques.
E-mail: rtrybulski.provita@gmail.com

Filipe Manuel CLEMENTE
Employment
Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Portugal
Degree
Ph.D.
Research interests
Athletic performance; sports training; performance analysis
E-mail: filipe.clemente5@gmail.com

✉ **Filipe Manuel Clemente**
Sport Physical Activity and Health Research & Innovation Center, 4900-347 Viana do Castelo, Portugal