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Exercise training in overweight and obese children: Recreational football and high-intensity interval training provide similar benefits to physical fitness

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This study compared the effects of recreational football and high-intensity interval training (HIIT) on body composition, muscular fitness, and cardiorespiratory fitness in overweight and obese children. Forty-two overweight/obese males aged 11-13 years [body mass index (BMI) >20.5 kg/m^2] were randomly assigned to a recreational football training group (n = 14; 157.9 ± 5.8 cm; 63.7 ± 12.6 kg), HIIT group (n = 14; 163.8 ± 9.4 cm; 71.5 ± 10.5 kg), or nontraining control group (n = 14; 162.7 ± 9.3 cm; 67.4 ± 16.1 kg). Physical fitness components were measured at baseline and after 12 weeks of training at the same time of the day and under similar conditions, including body composition, muscular fitness (lower-body power, change-of-direction speed, and flexibility), and cardiovascular fitness (Yo-Yo Intermittent Endurance test distance, resting heart rate, and blood pressure). Lean body mass (4.3%, ES = 0.40; 95% CI: −0.48, 1.29; *P* = .382) and muscle mass 4.4% (ES = 0.40; 95% CI: −0.48, 1.29; *P* = .378) *very likely* increased in the recreational football group, while *possible* improvements were observed in the HIIT group (lean body mass: 2.5%, ES = 0.22; 95% CI: −0.62, 1.06; *P* = .607, muscle mass: 2.8%, ES = 0.23; 95% CI: −0.61, 1.07; *P* = .594). Only *trivial* increases were observed in the control group for lean body mass (0.5%, ES = 0.05; 95% CI: −0.70, 0.79; *P* = .906) and muscle mass (1.1%, ES = 0.09; 95% CI: −0.65, 0.83; *P* = .814). Significant differences were found between the recreational football and control groups in post-training body mass (*P* = .034) and body mass index (*P* = .017). Body fat *very likely* decreased in the recreational football group (−7.7%, ES = −0.41; 95% CI: −1.29, 0.48; *P* = .376) and *possibly* decreased in the HIIT group (−5.2%, ES = −0.22; 95% CI: −1.05, 0.62; *P* = .607), with a *trivial* reduction in the control group (−1.1%, ES = −0.04; 95% CI: −0.78, 0.70; *P* = .914). *Very likely* increases in lower-body power were evident in the recreational football (17.0%, ES = 0.76; 95% CI: −0.15, 1.66; *P* = .107) and control groups (16.1%, ES = 0.55; 95% CI: −0.20, 1.31; *P* = .156), while *small* improvements were observed in the HIIT group (6.0%, ES = 0.24; 95% CI: −0.60, 1.08; *P* = .580, *possible*). *Likely* to *most likely* improvements in Yo-Yo Intermittent Endurance test performance and change-of-direction speed were noted in the recreational football group (Yo-Yo: 79.8%, ES = 1.09; 95% CI: 0.16, 2.03; *P* = .025, change-of-direction speed: −10.6%, ES = −1.05; 95% CI:

−1.98, −0.12; $P = .031$) and the HIIT group (Yo-Yo: 81.2%, ES = 1.03; 95% CI: 0.15, 1.92; $P = .025$, change-of-direction speed: −5.4%, ES = −0.91; 95% CI: −1.79, −0.04; $P = .045$). Diastolic blood pressure *likely* decreased in the recreational football (−8.6%, ES = −0.74; 95% CI: −1.64, 0.17; $P = .116$) and HIIT groups (−9.8%, ES = −0.57; 95% CI: −1.40, 0.30; $P = .195$), with a *possible* increase in the control group (1.2%, ES = 0.21; 95% CI: −0.53, 0.96; $P = .068$). Recreational football and HIIT elicited improvements in all muscular and cardiorespiratory fitness measures. In contrast, the control group, which performed only physical education classes, increased body mass, BMI, and fat mass. Therefore, additional activities such as recreational football or HIIT might counter the prevalence of overweight and obesity in children.

KEYWORDS

physical fitness, running, small-sided games, soccer

1 | INTRODUCTION

Childhood obesity has become a major public health problem despite being preventable. More than 340 million children and adolescents were overweight or obese worldwide in 2016.[1] Recent evidence on 24.1 million children and adolescents, aged 5-17 years, shows body mass index (BMI) increased 0.32 and 0.40 kg/m^2 per decade in girls and boys, respectively, from 1975 to 2016.[2] Accordingly, the global prevalence of obesity increased by 4.9% in girls and 6.9% in boys over the 42 years of analysis with no indication a plateau will be reached in the near future in most countries. It is well known that more than half of overweight and obese children will become obese adults[3] if they do not make appropriate lifestyle modifications such as increasing physical activity and reducing caloric intake.

Current evidence suggests that school programs provide a strong opportunity to increase physical activity because children spend more than half of their waking hours at school. Despite a recent meta-analysis[4] documenting longer school physical education (PE) programs (>1 year) were more likely to prevent childhood obesity, the prevalence of overweight and obese children is continuing to increase. Therefore, use of regular PE classes without additional physical activity to prevent childhood obesity is questionable. The major problems encountered during PE classes are the low average intensity and total amount of active time imposed upon children.[5] In this regard, only a small proportion of children (boys = 2.9%, girls = 1.8%) are sufficiently active during the entire class to meet physical activity guidelines.[6] Obviously, there is a need for additional physical activity that overcomes these issues, is time-efficient, and appeals to children given lack of time and motivation are two commonly cited activity barriers.

High-intensity interval training (HIIT) has been identified as a time-efficient form of exercise training to promote health benefits and improve fitness. Numerous meta-analyses have reported HIIT leads to improvements in body composition[7] and cardiorespiratory fitness[8-10] in healthy children and adults. In addition, some systematic evidence suggests HIIT is equal and in some cases more effective in improving physical fitness than traditional moderate-intensity endurance training in adults.[7,8] Despite these findings, only three studies[11-13] have investigated the effects of HIIT on health and fitness markers in younger overweight and obese populations. Specifically, existing evidence for HIIT training has only been provided for adolescent populations (aged 13-18 years) with comparisons between HIIT and low- or moderate-intensity training. Therefore, more intervention studies are needed to investigate the effects of HIIT specifically in overweight and obese children. To our knowledge, no study has examined the effects of HIIT in children aged 11-13 years nor compared the effect of HIIT with other forms of training imposing variable exercise intensities.

Recently, Oliveira et al[14] confirmed that group sports, mainly recreational football, improve body composition, cardiorespiratory fitness, and muscular fitness in overweight and obese children. In this regard, a growing number of systematic reviews and meta-analyses[15-18] have highlighted the utility of recreational football as a useful form of exercise training because of the intensity elicited [80%-85% of maximal heart rate (HR_{max})] and movement patterns experienced (~100 high-intensity runs). In turn, it is well established that recreational football induces a range of positive effects on physical fitness including lowering hypertension in middle-aged men and women, improving cardiovascular and metabolic responses in patients with type 2 diabetes, enhancing heart function, increasing physical capacity, improving muscle mass in prostate cancer patients, and increasing bone mineral density and mass.[17] In contrast, only two studies[19,20] have investigated the long-term effects of recreational football on physical fitness in obese boys with the authors concluding recreational football has the potential to prevent and reduce childhood obesity and associated health consequences. Moreover, recreational football has been shown to significantly improve health-related fitness, self-esteem, perceived physical competence, and attraction to physical activity, while PE classes had no effect on these measures.[19,20] In addition, Hansen et al[21] showed short-term recreational football training is suitable for positive structural and functional cardiovascular adaptations in overweight children. However, the short-term effects of recreational football on physical fitness in overweight and obese children are still unclear. Moreover, no study has compared the effects of recreational football and HIIT on physical fitness in overweight and obese children to directly assess the efficacy of each approach.

The purpose of this study was to compare the effects of recreational football and HIIT on (a) body composition, (b) muscular fitness, and (c) cardiorespiratory fitness measures in overweight and obese children. We hypothesized that recreational football will produce at least similar effects as HIIT because 15%-43% of total training time is spent working at greater than 90% HR_{max} during recreational football.[17]

2 | METHODS

2.1 | Participants

Forty-two overweight or obese male children, aged 11-13 years with no prior history of participation in regular exercise training were recruited to participate in this study. Participants were randomly assigned to football training (n = 14; 157.9 ± 5.8 cm; 63.7 ± 12.6 kg; 25.4 ± 4.1 kg/m^2), HIIT (n = 14; 163.8 ± 9.4 cm; 71.5 ± 10.5 kg; 26.6 ± 3.4 kg/m^2), or nontraining control groups (n = 14; 162.7 ± 9.3 cm; 67.4 ± 16.1 kg; 25.3 ± 4.8 kg/m^2). Recreational football and HIIT groups performed regular PE classes (2 times per week) plus the associated training intervention, while the control group participated only in PE classes. The process adopted for the enrollment, allocation, and drop-out of participants is shown in Figure 1. The inclusion criteria were as follows: (a) aged between 11 and 13 years and (b) overweight or obese according to the BMI classification by Cole et al.[22] Exclusion criteria were as follows: participation in organized exercise training in the last 6 months, participation in football training or additional recreational activities except PE classes, medical contraindication to training, and/or cardiorespiratory or respiratory disease. Participants were instructed to maintain their normal daily routines and to not partake in any other organized physical activity except PE classes. All participants and their parents/guardians were informed about the experimental procedures and provided written information consent prior to participation. The protocol was approved by

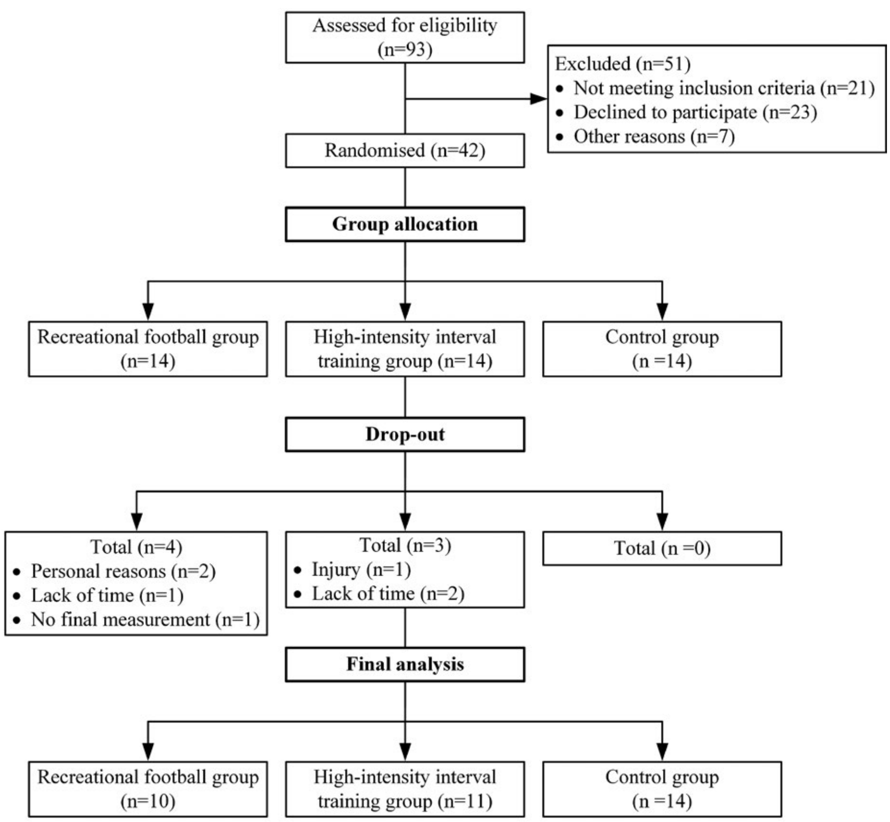

FIGURE 1 Flow chart of participant enrollment, randomized group allocation, and final analysis

the Ethics Committee of the Faculty of Sport and Physical Education with all procedures conducted in accordance with the Declaration of Helsinki.

2.2 | Study design

After baseline testing, participants were randomly allocated into football training, HIIT, or control groups by an investigator blinded to all baseline tests. Several physical fitness components were measured at baseline and after 12 weeks of training at the same time of the day and under similar conditions, including body composition, muscular fitness (lower-body power, change-of-direction speed, and flexibility), and cardiovascular fitness [Yo-Yo Intermittent Endurance test distance, resting heart rate (RHR), and blood pressure]. In the HIIT group, three participants left the exercise treatment due to lack of time to participate (n = 2) and injury (n = 1). Four participants left the football training group due to personal reasons (n = 2), lack of time (n = 1), and missed final measurement (n = 1). Accordingly, a total of 35 participants completed the study, with ten participants in the football training group, 11 in the HIIT group, and 14 in the control group. All participants trained more than the minimum requirement of 50% of the training sessions for inclusion in data treatment.

2.3 | Body composition

Total body scans were performed indoors using a multi-frequency bioelectrical impedance analyzer (InBody 720; Biospace Co. Ltd, Seoul, Korea) at frequencies of 1, 5, 50, 250, 500, and 1000 kHz under a controlled temperature of 23-28°C. This instrument uses a tetrapolar eight-point tactile electrode system (four in contact with the palm and thumb and the other four in contact with the feet) that separately measures impedance of the arms, trunk, and legs. Participants (wearing minimal clothing) placed their bare feet on the metal plates of the scale and grabbed the hand electrodes as instructed by the manufacturer. The InBody 720 automatically measures total body mass, fat mass, muscle mass, and lean (muscle and bone) mass in absolute terms to the nearest 0.05 kg and relative terms (%). Body height was measured using portable stadiometer (Seca 220; Seca Corporation, Hamburg, Germany) with a graduation of 0.1 cm.

2.4 | Muscular fitness

2.4.1 | Lower-body power

Maximal vertical jump height was assessed to the nearest 0.1 cm during a countermovement jump (CMJ) with arm swing using photoelectric cells consisting of two parallel bars (Optojump, Microgate, Bolzano, Italy), which measure flight time taken as the duration between take-off and landing. Participants were instructed to jump as high as possible, with a rapid, preparatory downward eccentric action while arms were freely able to be moved. All participants completed three jumps separated by 1 minute of passive recovery with the highest jump taken as the final outcome measure. The CMJ arm swing test is a valid and reliable field test for the assessment of muscular fitness.[23]

2.4.2 | Agility

The modified agility *t* test was administered using the protocol adopted by Sassi et al.[24] This test has been previously documented to possess acceptable reliability.[24] Participants began with both feet behind starting cone A, sprinted 5 m forward to cone B and touched it with the right hand before shuffling 2.5 m to the left to touch cone C with the left hand. Participants then shuffled 5 m to the right to touch cone D with the right hand, shuffled back to the central cone B to touch with the left hand, and finally sprinted through the timing gate at the original start position. Measurements were performed using electronic timing gates (Witty Timer, Bolzano, Italy) synchronized with a handheld computer to record sprint time to the nearest 0.001 second. All participants completed three trials with a 3-minute passive rest between each trial, and the best result was taken as the final outcome measure.

2.4.3 | Flexibility

The sit and reach test was administered using the protocol utilized by Sporis et al.[25] Each participant performed the sit and reach test sitting on the floor with both knees fully extended and the soles of the feet touching the first step (point recording zero). Participants were instructed to place one hand on the top of the other and slowly reach forward as far as possible keeping the knees extended. A sliding ruler centered on the top of the box was used to measure the distance between the tip of the fingers and toes to the nearest 0.01 cm. An attempt that does not reach the toes is negative and an attempt that surpasses the toes is positive. All participants completed three trials with 3 minutes of passive rest between each trial, and the best result was taken as the final outcome measure.

2.5 | Cardiorespiratory fitness

2.5.1 | Yo-Yo Intermittent Endurance test

Participants performed the Yo-Yo Intermittent Endurance test (level 1) involving 2 × 20-m runs at progressively increasing speeds controlled by audio bleeps from a prerecorded source (CD player), interspersed with 10-second active recovery periods consisting of 2 × 2.5-m jogs. The test ends when all runs are completed or if the distance is not reached in the allocated time upon the second occasion for each participant.

Heart rate (HR) was recorded using the Polar Team System H7 chest belt monitor (Polar Electro Oy, Kempele, Finland) to determine HR_{max} as previously described.[26] The total distance attained during the test was taken as the final outcome measure. The age-adapted Yo-Yo Intermittent Endurance test was previously confirmed as valid and reliable to assess aerobic fitness and intermittent high-intensity endurance in 9- to 16-year-old children.[26]

2.5.2 | Blood pressure

Blood pressure was measured in a seated position according to standard validated procedures using a manual sphygmomanometer.[27] Before measurement, each participant rested for 5 minutes in a seated position with back support. Manual systolic blood pressure (SBP) was estimated as the commencement of the Korotkoff sounds and diastolic blood pressure (DBP) taken at the complete cessation of sounds (K5).

2.5.3 | Heart rate

Heart rate was recorded using the Polar Team System H7 (Polar Electro Oy, Kempele, Finland). Validity and reliability of the Polar Team System H7 to measure R-R intervals have been supported previously.[28] The chest belt of the Polar Team System was positioned in accordance with manufacturer instructions. Participants laid on a bed with the head supported by a pillow while the signal from the chest was checked for interference and signal quality. For RHR, simultaneous R-R intervals were recorded during 10 minutes of silent rest. The HR response was also monitored continuously during all training sessions in all groups. The R-R interval data were transferred to a personal computer using the Polar software (Polar Precision Performance 4.03 software, Polar Electro OY, Kempele, Finland). Measurement errors and abnormal heartbeats were excluded by an automatic process in the software. HR data were later analyzed to compute the average HR response during training across the 12-week intervention. HR values were expressed as a percentage of individual HR_{max} determined during the Yo-Yo Intermittent Endurance test, time spent in very low (<60% HR_{max}), low (61%-70% HR_{max}) moderate (71%-80% HR_{max}), high (81%-90% HR_{max}), and maximal zones (>91% HR_{max}). In addition, the Polar software used proprietary patented algorithms to estimate energy expenditure (kCal) during every session in all groups.

2.6 | Training interventions

The football training and HIIT groups were supervised by at least one of the investigators and performed three times per week (Monday, Wednesday, and Friday) during the intervention period. All training sessions were separated by 48 hours to allow sufficient recovery. Football training was conducted outdoors on artificial grass and consisted of ordinary five- to seven-a-side matches with a relative pitch area of 80 m^2 per player and length to width aspect ratio of 2:1. Each training session lasted approximately 60 minutes, including a 10-minute low-intensity warm-up followed by 4 × 8-minute periods of play interspersed with 2 minutes of passive rest and ending with a 10-minute cool-down. Participants performed standardized warm-ups consisting of moderate-intensity jogging (4 minutes), static and dynamic stretching (4 minutes), and acceleration running (2 minutes). All matches were played without allocation of playing positions to each participant and in accordance with the general rules of football.

The HIIT program consisted of three sets of high-intensity interval runs separated by 3 minutes of passive rest. Interval distances were individually adjusted according to each participant's maximal aerobic speed (MAS) determined by the Half-Cooper test, which was performed at baseline and repeated every fourth week to update the training speed. During the Half-Cooper test, participants were instructed and verbally encouraged to cover as much distance as possible during the 6-minute period. MAS was calculated using the following formula: MAS (m/s) = distance covered (m)/360 (second). During weeks 0-4, weeks 5-8, and weeks 9-12, the training volume (number of repetitions and duration) was progressively increased. Each session during the entire training program involved work intervals of running effort at an intensity of 100% MAS interspersed by an equivalent amount of passive recovery (0% MAS). While training intensity was performed at 100% MAS, total training workload was calculated as arbitrary training units (ATU). ATU was calculated according to the following formula: ATU = {[(work intensity + rest intensity)/2] × number of repetitions × number of sets}. The distance for every participant was individually calculated by multiplying the achieved 100% MAS and work interval duration to obtain the same training intensity in every participant (eg, distance run = 3.5 m/s × 10 seconds = 35 m). A summary of the training plan and training load experienced in the HIIT program is presented in Table 1. Training consisted of a 10-minute warm-up protocol followed by high-intensity interval runs and ended with a 10-minute cool-down (warm-up protocol and cool-down were the same as the football training group). Participants started interval running from a standing position and followed audio signals to commence each subsequent run for the entire session. Upon completing each interval, participants immediately decelerated and were instructed to walk slowly to the next starting point and passively stand to await commencement of the next running interval. Every participant completed the running intervals in their own lane with fixed distances according to the calculated individualized MAS.

Participants in the control group continued their regular PE classes twice per week during the study period under the guidelines of the PE teacher according to the curriculum for

TABLE 1 Summary and training load of high-intensity interval training (HIIT) program

	Weeks 0-4	Weeks 5-8	Weeks 9-12
Work:rest interval duration (s)	10:10	15:15	20:20
Work:rest interval intensity	100:0% MAS	100:0% MAS	100:0% MAS
Number of repetitions	5	8	10
Number of sets	3	3	3
Rest between sets (s)	180	180	180
Training load	750 ATU	1200 ATU	1500 ATU
Weekly training load	2250 ATU	3600 ATU	4500 ATU

ATU: arbitrary training unit; MAS: maximal aerobic speed. ATU = {[(work intensity + rest intensity)/2] × number of repetitions × number of sets}; example of training load calculation for HIIT during the 0-4 wk: {[(100 + 0)/2] × 5 × 3} = 750 ATU.

their age category. Both intervention groups completed the same PE classes in addition to their training.

2.7 | Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences (v13.0; SPSS Inc., Chicago, IL, USA). Mean ± standard deviation, Kolmogorov-Smirnov (normality of the distribution), and Levene's (homogeneity of variance) tests were determined for all outcome measures. Changes in physical fitness parameters were compared over the training period for the experimental and control groups using two-factor (group × time) univariate analysis of variance (ANOVA). If the appropriate statistical significance was identified, then the Bonferroni post-hoc test was used to further distinguish the differences between groups. An analysis of covariance (ANCOVA) with baseline data as a covariate and groups as between-subject comparator was used to evaluate main and intervention effects. Cohen's *d* effect sizes (ES) were also calculated to determine the magnitude of the group differences in physical fitness. ES magnitude was interpreted as: *trivial* = <0.20; *small* = 0.2-0.59; *moderate* = 0.60-1.19; *large* = 1.20-1.99; and *very large* = >2.0.[29] Further, magnitude-based inferences were determined by quantifying the chances that true differences in all pairwise comparisons were greater than, similar to, or smaller than the smallest worthwhile difference (SWC = 0.2 multiplied by the between-participant deviation) and interpreted qualitatively as: *almost certainly not* = <0.5%; *very unlikely* = 0.5%-5%; *unlikely* = 5%-25%; *possible* = 25%-75%; *likely* = 75%-95%; *very likely* = 95%-99.5%; and *almost certain* = >99.5%.[29] Statistical significance was set at $P < .05$.

3 | RESULTS

The Kolmogorov-Smirnov tests showed all data were normally distributed, and no violation of homogeneity of variance was found using Levene's test. HR distribution in relation to percentage of training time in target HR zones is presented in Figure 2. The average training intensity in the recreational football, HIIT, and control groups was 75.1 ± 2.3%, 80.0 ± 3.0%, and 68.3 ± 2.2% HR_{max}, respectively. Additionally, average caloric expenditure per training session was 496 ± 43, 416 ± 59, and 320 ± 32 kCal in the recreational football, HIIT, and control groups, respectively.

3.1 | Body composition

A significant difference was found between the recreational football and control groups in post-training body mass (P = .034) and BMI (P = .017) (Table 2). The recreational football group experienced a *trivial* decrease in body mass (−1.4%, ES = −0.07; 95% CI: −0.94, 0.81; P = .879), while the control group exhibited a *possible* increase in body mass (5.7%, ES = 0.24, *small,* 95% CI: −0.50, 0.99; P = .523). Likewise, nonsignificant changes (P > .05) between initial and final measurement, as well as between groups, were observed for lean body mass, muscle mass, and fat mass. However, percentage of lean body mass (4.3%, ES = 0.40, *small*, 95% CI: −0.48, 1.29; P = .382) and muscle mass

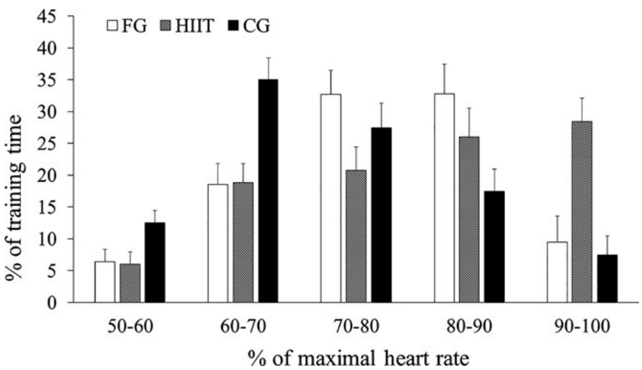

FIGURE 2 Distribution of heart rate (HR) in relation to percentage of training time in target HR zones; CG: control group; FG: football group; HIIT: high-intensity interval training group

TABLE 2 Body composition parameters for football, high-intensity interval training (HIIT), and control groups before and after the 12-wk training intervention

	Football group (n = 10)			HIIT group (n = 11)			Control group (n = 14)			ANCOVA main effect (*P*-value)
	Initial	Final	Δ (%)	Initial	Final	Δ (%)	Initial	Final	Δ (%)	
Body height (cm)	157.90 ± 5.80	159.20 ± 5.72	0.8	163.82 ± 9.36	164.60 ± 9.09	0.5	162.68 ± 9.29	164.57 ± 8.42	1.2	.567
Body mass (kg)	63.70 ± 12.61	62.81 ± 13.06[a]	−1.4	71.49 ± 10.52	71.53 ± 11.23	0.1	67.35 ± 16.07	71.18 ± 15.28	5.7	.034
Body mass index (kg/m^2)	25.43 ± 4.05	24.65 ± 4.22[a]	−3.1	26.62 ± 3.36	26.35 ± 3.33	−1.0	25.29 ± 4.77	26.16 ± 4.49	3.4	.017
Body fat mass (%)	36.25 ± 6.70	33.47 ± 6.99	−7.7	32.85 ± 8.29	31.15 ± 6.90	−5.2	29.94 ± 8.41	29.60 ± 7.68	−1.1	.482
Body fat mass (kg)	23.54 ± 7.96	21.60 ± 8.47	−8.2	23.51 ± 7.09	22.36 ± 6.41	−4.9	20.68 ± 10.84	21.55 ± 10.16	4.2	.086
Lean body mass (kg)	40.16 ± 6.20	41.21 ± 5.95	2.6	47.98 ± 9.20	49.17 ± 8.86	2.5	46.67 ± 9.60	49.63 ± 9.18	6.3	.158
Lean body mass (%)	63.76 ± 6.72	66.50 ± 6.99	4.3	67.13 ± 8.27	68.83 ± 6.88	2.5	69.96 ± 8.40	70.33 ± 7.67	0.5	.510
Muscle mass (kg)	21.78 ± 3.68	22.37 ± 3.55	2.7	26.35 ± 5.40	27.06 ± 5.21	2.7	25.67 ± 5.75	27.46 ± 5.47	7.0	.132
Muscle mass (%)	34.51 ± 3.70	36.03 ± 3.79	4.4	36.80 ± 4.83	37.83 ± 3.99	2.8	38.42 ± 4.94	38.85 ± 4.58	1.1	.755

Δ (%)—percent change between initial and final measurement.
[a]Significant difference between football group and control group at final measurement ($P < .05$).

(ES = 0.40, *small*, 95% CI: −0.48, 1.29; *P* = .378) exhibited *very likely* increases in the recreational football group, while *possible* improvements were observed in the HIIT group (lean body mass: 2.5%, ES = 0.22, *small,* 95% CI: −0.62, 1.06; *P* = .607, muscle mass: 2.8%, ES = 0.23, *small,* 95% CI: −0.61, 1.07; *P* = .594). A *trivial* increase was evident in the control group for lean body mass (0.5%, ES = 0.05; 95% CI: −0.70, 0.79; *P* = .906) and muscle mass (1.1%, ES = 0.09; 95% CI: −0.65, 0.83; *P* = .814). Likewise, body fat exhibited *very likely* decreases in the recreational football (−7.7%, ES = −0.41, *small,* 95% CI: −1.29, 0.48; *P* = .376) and control groups (−1.1%, ES = 0.04, *trivial*, 95% CI: −0.78, 0.70; *P* = .914) compared to *possible* reductions in the HIIT group (−5.2%, ES = −0.22, *small*, 95% CI: −1.05, 0.62; *P* = .607). *Trivial* decreases in BMI were apparent in the recreational football (−3.1%, ES = −0.19; 95% CI: −1.06, 0.69; *P* = .678) and HIIT groups (−1.0%, ES = −0.08; 95% CI: −0.91, 0.76; *P* = .855), and there were no significant differences between groups ($P > .05$). In contrast, the control group displayed a *trivial* increase in BMI (3.4%, ES = 0.19; 95% CI: −0.56, 0.93; *P* = .625).

3.2 | Muscular fitness

Lower-body power *very likely* increased in the recreational football (17.0%, ES = 0.76, *moderate*, 95% CI: −0.15, 1.66; *P* = .107) and control groups (16.1%, ES = 0.55, *small*, 95% CI: −0.20, 1.31; *P* = .156), while *possible* improvements were observed in the HIIT group (6.0%, ES = 0.24, *small*, 95% CI: −0.60, 1.08; *P* = .580), without significant differences between groups (Table 3). Comparisons between initial and final measurements showed a significant ($P < .05$), *most likely* improvement in modified agility *t* test performance in the recreational football group (−10.6%, ES = −1.05, *moderate*, 95% CI: −1.98, −0.12; *P* = .031). Similarly, a significant ($P < .05$), *likely* improvement was observed in the HIIT group (−5.4%, ES = −0.91, *moderate*, 95% CI: −1.79, −0.04; *P* = .045), while a nonsignificant, *most likely* faster time was noticed in the control group (−5.0%, ES = −0.76, *moderate*, 95% CI: −1.52, 0.01; *P* = .056). Flexibility *very likely* increased in the recreational football (78.7%, ES=0.76, *moderate*, 95% CI: −0.14, 1.67; *P* = .105) and HIIT groups (40.2%, ES = 0.60, *moderate*, 95% CI: −0.25, 1.46; *P* = .173) with *likely* improvements in the control group (21.1%, ES=0.31, *small*, 95% CI: −0.44, 1.05; *P* = .423) without significant differences between groups ($P > .05$).

3.3 | Cardiorespiratory fitness

Significant ($P < .05$) pre-to-post improvements were observed for total distance covered in the Yo-Yo Intermittent Endurance test in the recreational football (79.8%, ES = 1.09, *moderate*, 95% CI: 0.16, 2.03; *P* = .025) and HIIT groups (81.2%, ES = 1.03, *moderate*, 95% CI: 0.15, 1.92; *P* = .025),

TABLE 3 Muscular and cardiorespiratory fitness parameters for football, high-intensity interval training (HIIT), and control groups before and after the 12-wk training intervention

	Football group (n = 10)			HIIT group (n = 11)			Control group (n = 14)			ANCOVA main effect
	Initial	Final	Δ (%)	Initial	Final	Δ (%)	Initial	Final	Δ (%)	(*P*-value)
Muscular fitness										
CMJ with arm swing (cm)	17.57 ± 4.24	20.56 ± 3.62	17.0	22.21 ± 5.39	23.54 ± 5.73	6.0	21.42 ± 6.72	24.86 ± 5.68	16.1	.123
Agility *t* test	8.58 ± 1.05	7.67 ± 0.63*	−10.6	7.84 ± 0.61	7.41 ± 0.26*	−5.4	8.06 ± 0.57	7.66 ± 0.49	−5.0	.154
Sit and reach (cm)	5.00 ± 3.73	8.93 ± 6.27	78.7	11.48 ± 7.47	16.10 ± 7.85	40.2	10.33 ± 6.97	12.51 ± 7.18	21.1	.182
Cardiorespiratory fitness										
Yo-Yo test (m)	476.0 ± 182.4	856.0 ± 456.0*	79.8	567.2 ± 305.6	1028.0 ± 552.4*	81.2	722.8 ± 576.0	857.2 ± 542.0	18.6	.057
Resting HR (b.p.m.)	86.30 ± 12.95	77.50 ± 9.50[a]	−10.2	88.36 ± 15.11	76.90 ± 11.11[b]	−13.0	79.57 ± 7.11	84.15 ± 9.83	5.8	.003
Maximal HR (b.p.m.)	211.50 ± 8.32	203.90 ± 3.07*	−3.6	203.36 ± 4.97	198.30 ± 2.90*[b]	−2.5	202.00 ± 9.58	200.72 ± 3.89	−0.6	.003
SBP (mm/Hg)	121.00 ± 11.74	117.50 ± 11.12	−2.9	123.64 ± 12.47	116.50 ± 14.15	−5.8	123.93 ± 15.34	124.85 ± 11.58	0.7	.192
DBP (mm/Hg)	70.00 ± 10.80	64.00 ± 3.94	−8.6	73.18 ± 15.85	66.00 ± 8.00	−9.8	62.68 ± 9.29	64.57 ± 8.42	1.2	.798

Δ (%)—percent changes between initial and final measurement.

CMJ: countermovement jump; DBP: diastolic blood pressure; HR: heart rate; SBP: systolic blood pressure.

[a]Significant difference between football group and control group at final measurement ($P < .05$).

[b]Significant difference between HIIT and control group at final measurement ($P < .05$).

*Significant difference between initial and final measurement.

while a nonsignificant, *possible* increase was noted in the control group (18.6%, ES= 0.24, *small*, 95% CI: −0.50, 0.98; P = .423). After the training intervention, an *unclear* decrease in SBP was evident in the recreational football group (−2.9%, ES = −0.31, *small*, 95% CI: −1.19, 0.58; P = .502) and a *likely decrease* in the HIIT group (−5.8%, ES = −0.54, *small*, 95% CI: −1.38, 0.31; P = .224) (Table 4). *Likely* decreases in DBP were observed in the recreational football (−8.6%, ES = −0.74, *moderate*, 95% CI: −1.64, 0.17; P = .116) and HIIT groups (−9.8%, ES = −0.57, *small*, 95% CI: −1.40, 0.30; P = .195). In contrast, *unclear* and *possible* increases in SBP (0.7%, ES = −0.07, *trivial*, 95% CI: −0.67, 0.81; P = .860) and DBP (1.2%, ES = −0.21, *small*, 95% CI: −0.53, 0.96; P = .068) were observed in the control group, respectively. RHR *very likely* decreased in the recreational football (−10.2%, ES = −0.77, *moderate*, 95% CI: −1.68, 0.13; P = .100) and HIIT groups (−13.0%, ES = −0.86, *moderate*, 95% CI: −1.74, 0.01; P = .056), and *likely* increased (5.8%, ES = 0.53, *small*, 95% CI: −0.22, 1.29; P = .169) in the control group, with significant differences between recreational football and control groups (P = .017) as well as between HIIT and control groups (P = .005). A nonsignificant time × group interaction was observed between HIIT and control groups in maximal HR (P = .060).

4 | DISCUSSION

This study compared the short-term effects of recreational football and HIIT in addition to PE classes (used as a control) on body composition, muscular fitness, and cardiorespiratory fitness in overweight and obese children. The major findings were recreational football and HIIT promoted significant, *moderate* pre-to post improvements in intermittent exercise and change-of-direction speed and a significant lowering of maximal HR. The magnitude of changes was higher with the recreational football intervention compared to HIIT and control groups in body composition, muscular fitness, intermittent exercise performance, and DBP. To the contrary, HIIT produced greater reductions in RHR, maximal HR, and SBP than the recreational football and control groups. The control group increased body mass and BMI with *trivial* to *small* changes in all other body composition parameters. Significant differences were found between recreational football and control groups in body mass, BMI, and RHR following the training program. Moreover, maximal HR and RHR were significantly lower in the HIIT group compared to the control group post-training.

4.1 | Body composition

One of the most sustainable and beneficial approaches to counter childhood obesity is activity, which can be administered via sports, exercise training, and school programs. BMI and body fat mass were reduced by 3.1% and 8.2% (2.0 kg) after 12 weeks of recreational football training in overweight and obese children, whereas completing all activity through PE classes increased BMI (3.4%) and body fat mass (4.2%). This magnitude of response is threefold higher for BMI and similar for body fat mass compared to recent studies investigating the long-term[19] and short-term[21] effects of recreational football in overweight and obese children. In contrast to our results, some recreational football and team sports training interventions in overweight and obese children induced increases in body mass and BMI despite a twofold longer intervention period.[14,20,30] Contradictory results in the aforementioned studies may be related to age of the participants examined, which are characterized by rapid biological growth and development with significant gains in body mass and height.[14] In the studies[19,21] where body height displayed minimal changes (<1.0 cm), BMI decreased, while in studies[20,30] with greater height increases, BMI increased. In contrast, HIIT showed trivial changes in BMI and fat mass which may be related to the fact that the total energy expenditure is limited during interval training[8] and PE classes.[5] Our findings are similar to Krustrup et al[31] who found a significant decline in body fat in a recreational football group and comparable running group, with no significant changes in HIIT, short-term strength training, and control groups. Therefore, the present study confirms recreational football has high total energy expenditure leading to greater energy consumption and consequently directly promoting body fat reduction. In addition, intermittent low- to moderate-intensity activities during recreational football might increase fat oxidation compared to HIIT.[32] The present data demonstrate recreational football training interventions lasting 12 weeks (3 × 60-minute sessions/week) can promote a decrease in total fat mass of 1-3 kg, which is clinically significant for overweight and obese children.[17]

Aligning with previous recreational football research,[17] total body mass decreased slightly in the football intervention in the present study as there was a concomitant increase in lean body mass of 1.1 kg. Our results are in accordance with a recent study by Seabra et al[19] who observed a decrease in body mass of 1.5 kg across a 6-month football intervention in obese male children. An increase in lean body mass with recreational football may be related to multiple strength training elements and frequent performance of intense actions such as dribbles, shots, tackles, turns, and jumps in training sessions.[33] Similar improvements in lean body mass were observed in the HIIT group, which might be expected given HIIT has similar metabolic adaptations as traditional high volume endurance training.[34] HIIT increases maximal oxidative capacity, enhances lipid metabolism, improves metabolic control, and enhances markers of skeletal muscle function.[34] Increased muscle mass with recreational football training

TABLE 4 Magnitude-based inferences and absolute changes between initial and final measurements in football, high-intensity interval training (HIIT), and control group

	Football group (n = 10)			HIIT group (n = 11)			Control group (n = 14)		
	Raw diff (95% CI)	ES (95% CI)	MBI	Raw diff (95% CI)	ES (95% CI)	MBI	Raw diff (95% CI)	ES (95% CI)	MBI
Body composition									
Body height (cm)	1.30 (0.69, 1.91)	0.23 (−0.65, 1.10)	Possibly positive	0.78 (−1.38, 2.94)	0.08 (−0.75, 0.92)	Likely trivial	1.89 (−0.25, 4.03)	0.21 (−0.53, 0.96)	Possibly positive
Body mass (kg)	−0.89 (−2.34, 0.56)	−0.07 (−0.95, 0.81)	Very likely trivial	0.04 (−1.50, 1.58)	0.00 (−0.84, 0.84)	Very likely trivial	3.83 (−0.03, 7.70)	0.24 (−0.50, 0.99)	Possibly positive
BMI (kg/m^2)	−0.78 (−1.30, −0.26)	−0.19 (−1.07, 0.69)	Possibly trivial	−0.26 (−1.11, 0.58)	−0.08 (−0.91, 0.76)	Likely trivial	0.87 (−0.12, 1.85)	0.19 (−0.56, 0.93)	Possibly trivial
Body fat mass (%)	−2.78 (−4.22, −1.34)	−0.41 (−1.29, 0.48)	Very likely negative	−1.70 (−4.78, 1.38)	−0.22 (−1.06, 0.62)	Possibly negative	−0.33 (−1.45, 0.78)	−0.04 (−0.78, 0.70)	Very likely trivial
Body fat mass (kg)	−1.94 (−3.25, −0.63)	−0.24 (−1.12, 0.64)	Possibly negative	−1.15 (−3.58, 1.29)	−0.17 (−1.01, 0.67)	Possibly trivial	0.87 (−0.71, 2.44)	0.08 (−0.66, 0.82)	Likely trivial
Lean body mass (kg)	1.05 (0.18, 1.92)	0.17 (−0.71, 1.05)	Possibly trivial	1.19 (−0.76, 3.14)	0.13 (−0.70, 0.97)	Likely trivial	2.96 (0.42, 5.50)	0.32 (−0.43, 1.06)	Likely positive
Lean body mass (%)	2.75 (1.28, 4.21)	0.40 (−0.48, 1.29)	Very likely positive	1.70 (−1.41, 4.80)	0.22 (−0.62, 1.06)	Possibly positive	0.36 (−0.75, 1.48)	0.05 (−0.70, 0.79)	Very likely trivial
Muscle mass (kg)	0.59 (0.09, 1.09)	0.16 (−0.71, 1.04)	Possibly trivial	0.72 (−0.40, 1.84)	0.14 (−0.70, 0.97)	Likely trivial	1.79 (0.28, 3.30)	0.32 (−0.43, 1.06)	Likely positive
Muscle mass (%)	1.51 (0.71, 2.32)	0.40 (−0.48, 1.29)	Very likely positive	1.02 (−0.73, 2.77)	0.23 (−0.61, 1.07)	Possibly positive	0.43 (−0.16, 1.01)	0.09 (−0.65, 0.83)	Very likely trivial
Muscular fitness									
CMJ arm (cm)	2.99 (1.35, 4.63)	0.76 (−0.15, 1.66)	Very likely positive	1.33 (−0.25, 2.92)	0.24 (−0.60, 1.08)	Possibly positive	3.44 (1.85, 5.03)	0.55 (−0.20, 1.31)	Very likely positive
Agility *t* test	−0.91 (−1.30, −0.52)	−1.05 (−1.98, −0.12)	Most likely negative	−0.43 (−0.80, −0.05)	−0.91 (−1.79, −0.04)	Likely negative	−0.40 (−0.57, −0.23)	−0.76 (−1.52, 0.01)	Most likely negative
Sit and reach (cm)	3.93 (1.61, 6.26)	0.76 (−0.14, 1.67)	Very likely positive	4.62 (1.99, 7.24)	0.60 (−0.25, 1.46)	Very likely positive	2.18 (0.62, 3.74)	0.31 (−0.44, 1.05)	Likely positive
Cardiorespiratory fitness									
Yo−Yo test (m)	380 (105.79, 654.21)	1.09 (0.16, 2.03)	Very likely positive	460.8 (212.11, 709.34)	1.03 (0.15, 1.92)	Most likely positive	134.4 (2.51, 266.06)	0.24 (−0.50, 0.98)	Possibly positive
Resting HR (b.p.m.)	−8.80 (−16.29, −1.31)	−0.77 (−1.68, 0.13)	Very likely negative	−11.46 (−17.43, −5.50)	−0.86 (−1.74, 0.01)	Very likely negative	4.58 (−1.02, 10.19)	0.53 (−0.22, 1.29)	Likely positive

(Continues)

TABLE 4 (Continued)

	Football group (n = 10)			HIIT group (n = 11)			Control group (n = 14)		
	Raw diff (95% CI)	ES (95% CI)	MBI	Raw diff (95% CI)	ES (95% CI)	MBI	Raw diff (95% CI)	ES (95% CI)	MBI
Maximal HR (b.p.m.)	−7.60 (−12.04, −3.16)	−1.21 (−2.16, −0.26)	Very likely negative	−5.06 (−7.67, −2.45)	−1.25 (−2.15, −0.34)	Most likely negative	−1.28 (−5.06, 2.50)	−0.17 (−0.92, 0.57)	Possibly trivial
SBP (mm/Hg)	−3.50 (−11.42, 4.42)	−0.31 (−1.19, 0.58)	Unclear	−7.14 (−16.75, 2.48)	−0.54 (−1.38, 0.31)	Likely negative	0.92 (−8.71, 10.54)	0.07 (−0.67, 0.81)	Unclear
DBP (mm/Hg)	−6.00 (−14.56, 2.56)	−0.74 (−1.64, 0.17)	Likely negative	−7.18 (−16.33, 1.96)	−0.57 (−1.40, 0.30)	Likely negative	1.89 (−14.30, 0.12)	0.21 (−0.53, 0.96)	Possibly positive

95% CI: 95% confidence interval; BMI: body mass index; CMJ arm: countermovement jump with arm swing; DBP: diastolic blood pressure; ES: effect size; HR: heart rate; MBI: magnitude-based inferences interpretation; SBP: systolic blood pressure.

and HIIT may hold further health benefits. For instance, a higher muscle mass can influence glucose tolerance due to an induced increase in glucose transporters[31] where short and intense exercise provides an adequate stimulus to improve insulin action.[35] This response is clinically important because the insulin response is associated with multiple cardiovascular risk factors in overweight and obese children.[36]

4.2 | Muscular fitness

Muscular fitness is widely recognized as a key fitness component in maintaining overall health possessing an inverse association with adiposity.[37] In the present study, recreational football training and HIIT showed significant improvements in change-of-direction speed. The improvements in change-of-direction speed we observed are higher than those observed following 6 months of recreational football or standard sports training programs in overweight and obese children.[20] The slower change-of-direction speed at baseline in our study and less familiarization with physical fitness testing in overweight and obese children documented[38] may underpin these discrepancies across studies. In addition, the superior improvements in change-of-direction speed observed with recreational football compared to HIIT in our study may be due to the higher number of change-of-direction maneuvers during small-sided football games, which may promote improved balance, strength, and body control without loss of speed.[39] The HIIT consisted of short linear running intervals with multiple 180° turns, likely promoting enhanced rotational speed and body control for improved change-of-direction speed. Nevertheless, the magnitude of change was twofold higher for the recreational football group than the HIIT group (−10.6% vs −5.4%), likely due to the modified agility *t* test implemented in this study containing multidirectional accelerations and changes in direction that are more specific to recreational football movement patterns than HIIT.

A recent meta-analysis[17] confirmed recreational football training was *moderately* beneficial for muscle power, which is in line with results observed in this study. Slightly smaller improvements in CMJ height (2.99 vs 2.30 cm) were found in previous long-term recreational football research;[20] however, CMJ was performed without arm swing by the overweight and obese children examined. This methodological discrepancy across studies is important given recreational football imposes frequent upper-body demands with recruitment of the arms used repeatedly across matches. In contrast, the HIIT group showed smaller improvements (6.0%) compared to the recreational football group (17.0%). The increase in CMJ with recreational football training in the present study may be partly related to the greater decrease in body mass. However, the increase in CMJ performance was larger than the decrease in body mass, and the improvement in jump performance was higher in the football group than the HIIT group despite similar changes in body mass and body composition. A potential mechanism underpinning these findings is that recreational football training has been shown to include more jumps and explosive arm movements than HIIT,[40] which together may improve CMJ performance with arm swing. In line with our results, a previous meta-analysis[7] confirmed a *small* effect of HIIT on muscle power due to a lack of training specificity in the HIIT protocols that predominantly involve running and sprinting without focused vertical expressions of power.

The wide positive effects of recreational football and HIIT on fitness in overweight and obese children were supported by *moderate* improvements in flexibility after 12 weeks of football training and HIIT. In contrast, group sports showed overall small improvements (ES = 0.26; 95% CI: −0.16-0.68) in flexibility in overweight and obese children.[14] The magnitude of changes documented in the present study was lower than observed in middle-aged men[41] and similar to middle-aged female hospital employees[42] after the same volume of recreational football training. The results may be partly attributed to stretching exercises administered during the warm-up and cool-down protocols, which were the same in both intervention groups in this study. Faude et al[20] did not incorporate flexibility exercises as a part of training and observed a small effect (ES = 0.25) despite administration of a long-term recreational football intervention. Therefore, stretching protocols during warm-up and cool-down periods may play an important role and may be valuable for flexibility improvement. Despite there being a nonsignificant difference, *moderate* improvements observed in both intervention groups holds functional practical application for overweight and obese children during everyday activities such as dressing, showering, or climbing stairs.

4.3 | Cardiorespiratory fitness

Obese and overweight children have been shown to possess lower cardiorespiratory fitness than healthy weight children, which increases the risk of developing cardiovascular diseases.[43] Even a small increase in cardiorespiratory fitness markedly reduces the risk of developing cardiovascular diseases and premature mortality.[44] A major finding of the present study was cardiorespiratory fitness significantly increased with football training and HIIT, whereas no significant changes were observed for the control group. The significant, *moderate* improvements we observed are similar to those documented after a group sports intervention in overweight and obese children.[14] In addition, HR_{max} significantly decreased after football training and HIIT while RHR was *moderately* reduced. Lower HR_{max} and RHR are consequences of cardiocirculatory system adaptation[20] stemming from frequent high-intensity movements performed during recreational football and HIIT. Given most of the participants in this study had poor aerobic fitness at baseline, an improvement might have been expected with training. Milanović et al[18] systematically analyzed the effects of recreational football on aerobic fitness and concluded this form of exercise produces large improvements (3.51 mL/kg/min), which is similar to our data (3.20 mL/kg/min). One of the reasons for the large improvements in cardiorespiratory fitness with football training is the frequent changes in activity intensity despite participants working at 75% HR_{max} on average, which is lower than intensities observed in meta-analyzed studies (80% HR_{max}).[18] In addition, participants in our study spent only 10% of training time above 90% HR_{max} during football training, which is lower than that observed in other studies (~20%).[16-18,41] However, the stimuli elicited during the football training were sufficient for overweight and obese children to undergo similar aerobic adaptations for improved fitness to other research.[14,20] Hansen et al[21] concluded typical patterns of cardiovascular adaptations related to recreational football have similarities to interval training. A previous meta-analysis also showed HIIT increased aerobic fitness by 2.6 mL/kg/min in adolescents, which is slightly lower than the 3.1 mL/kg/min observed in this study. In contrast, the present values are lower than the reported improvements in cardiorespiratory fitness in middle-aged men with HIIT (5.5 mL/kg/min).[8] HIIT elicited large improvements in cardiorespiratory fitness of overweight and obese children because this type of training has been shown to induce central (cardiovascular) and peripheral (skeletal muscle) aerobic adaptations.[45] In addition, HIIT leads to large increases in cellular and peripheral vascular function,[45] which promotes enhanced cardiovascular function to tolerate higher aerobic workloads.

A strong relationship has been established between overweight or obese children and elevated blood pressure. In turn, recreational football training decreased SBP and DBP by 2.9% and 8.6%, respectively. Similar research[21] noted 1.5% decreases in SBP and DBP; however, baseline values for SBP and DBP were higher in our study and likely influenced the magnitude of changes. In contrast, previous long-term examination[19] of overweight and obese children demonstrated an increase in SBP (0.4%) and decrease in DBP (−7.3%) after undertaking long-term recreational football training. Krustrup et al[15] explained recreational football training is superior to other forms of exercise in lowering DBP through improved muscle capillarization, decreased arterial stiffness, and increased cardiac relaxation time. In addition, short-term recreational football intervention was related to increased left ventricular posterior wall diameter, isovolumetric relaxation time, and tricuspid annular plane systolic excursion in overweight and obese children.[21] The aforementioned changes were accompanied with elevated peak systolic velocity[21] which led to improved systolic and diastolic myocardial function.[46] Despite recreational football promoting superior changes in blood pressure than HIIT in the present study, the observed difference was not significant. Previous analyses[47] concluded HIIT produced a greater decrease in blood pressure compared to other forms of exercise such as continuous running or strength training. However, our results showed the magnitude of decreases in blood pressure responses is higher with recreational football training, suggesting it may hold greater vascular benefits than HIIT. Unfortunately, physiological mechanisms underpinning cardiovascular function were not fully elucidated in this study and further research is needed to better understand the physiological benefits of football training and HIIT on blood pressure.

While the present study offers several beneficial outcomes, some limitations require acknowledgement. First, we performed research on a relatively small sample size, which may explain the nonsignificant differences observed despite similar or higher magnitudes in changes compared to previous studies. Second, we investigated only overweight and obese males; therefore, future studies should focus on both sexes to understand the specific effects of recreational football training and HIIT on male and female children. Third, we did not control habitual energy intake during the intervention, which may have influenced the overall results. Future studies should combine nutritional interventions in combination with recreational football training or HIIT to identify the most effective strategy in preventing or reducing childhood obesity. Finally, the PE classes delivered to the present sample of children might differ in the activities imposed to classes in other geographical locations. Consequently, similar research is encouraged across various countries to assess the effectiveness of school programs on markers of physical fitness in overweight and obese children.

5 | CONCLUSION

In conclusion, recreational football and HIIT showed improvements in multiple measures of muscular and cardiorespiratory fitness after 12 weeks of training in overweight and obese male children. While both interventions improved physical fitness, recreational football training enhanced all physical fitness measures to a greater degree than HIIT. In contrast, the control group, which performed only PE classes, showed *trivial* to *small* changes over the 12-week intervention where body mass, BMI, and fat mass actually increased. Obviously, PE classes are not enough to reduce the prevalence of obesity among school-age populations. Therefore, additional activity such as recreational football training or HIIT may offer a viable solution to counter overweight and obesity in children.

6 | PERSPECTIVE

The present findings show performing two PE classes per week to increase activity in overweight and obese children is not effective at producing short-term improvements in physical fitness. Consequently, schools might consider implementing activities performed in classes that have been supported to promote fitness improvements in overweight and obese children where safe to do so, such as recreational football or HIIT. Moreover, schools can use HIIT during recess to overcome lack of time as barrier and improve the chances of long-term adherence for individuals who are not active. In contrast, recreational football as game-play type of activity might interest students more than traditional exercises and improve motivation and social aspects of training. Importantly, recreational football showed broad-spectrum positive effects on physical fitness and therefore the "Football is Medicine" concept could become an important part of the wider movement, "Exercise is Medicine."

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest in relation to this article.

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