ORIGINAL ARTICLE

Effects of 3x3 progressive cycling interval training on cardiovascular fitness and body composition in overweight undergraduates

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Abstract

Background and Study Aim	Obesity has become a global health concern and high-intensity interval training (HIIT) has emerged as an effective exercise modality for improving body composition, promoting weight loss, and increasing cardiovascular fitness. This study aimed to investigate the effects of progressive 3 by 3 cycling interval training on cardiovascular fitness and body composition in overweight individuals.
Material and Methods	Fifteen overweight undergraduate students were recruited (age = 20.2 ± 0.7 years; body weight = 78.2 ± 16.2 kg; BMI = 27.2 ± 3.7 kg/m²; height = 168.9 ± 8.0 cm). The participants engaged in an 8-week progressive 3 by 3 cycling interval training program, consisting of 3 sessions per week. Body composition was measured using bioelectrical impedance analysis, blood lipid profiles were tested, and maximum oxygen consumption (VO$_2$max) was assessed at baseline and after the intervention. A one-way ANOVA was conducted to evaluate changes between pre- and post-intervention measurements.
Results	The findings demonstrated that there were no significant changes in body composition parameters, including body weight, BMI, body fat percentage, fat mass, and visceral fat (all $p > 0.05$, all ES = Trivial). Similarly, blood lipid profile parameters were also not significantly changed between pre-intervention and post-intervention (all $p > 0.05$, all ES = Trivial). However, VO$_2$max significantly increased after 8 weeks of training (95% CI = 1.27–8.25 ml·kg^{-1}·min^{-1}, ES = Moderate, $p = 0.011$).
Conclusions	The progressive 3 by 3 cycling interval training was effective in enhancing cardiovascular fitness in overweight individuals and may help reduce cardiovascular risk associated with low VO$_2$max.
Keywords:	high intensity interval training, cycling interval training, VO$_2$max, obesity, body composition

Introduction

Obesity has emerged as a significant global health concern, contributing to various chronic conditions and reduced quality of life. High-intensity interval training (HIIT) has gained attention as an effective approach for improving cardiovascular fitness and managing body composition. The problem of excess weight is increasingly affecting the student population, highlighting the need for more effective solutions.

In this context, obesity has become a global health concern, affecting individuals across all age groups and socioeconomic statuses [1]. Characterized by the excessive accumulation of body fat and a high body mass index (BMI), obesity significantly increases the risk of numerous health complications, including cardiovascular disease, type 2 diabetes, and certain cancers [2]. The condition also places a considerable economic burden on healthcare systems worldwide, contributing to increased medical costs and reduced productivity [3]. Obesity is not limited to middle-aged or older adults; it also affects younger individuals and is often driven by a combination of poor dietary habits and sedentary lifestyles [4]. Furthermore, the chronic low-grade inflammation associated with obesity exacerbates metabolic dysfunction, leading to insulin resistance and dyslipidemia [5]. Addressing obesity requires a multifaceted approach that incorporates lifestyle interventions, such as dietary modifications and regular physical exercise programs [6].

For exercising, high-intensity interval training (HIIT) has emerged as an effective exercise modality for improving body composition and promoting weight loss [7]. HIIT alternates short bursts of intense physical activity with recovery periods, making it time-efficient and adaptable for various populations [8]. It has been studied for its ability to increase cardiovascular fitness, enhance metabolic rate, improve fat oxidation, and preserve lean muscle mass [9, 10, 11]. Unlike traditional steady-state aerobic exercise, HIIT induces greater post-exercise oxygen consumption, further accelerating caloric expenditure [12]. These versatile benefits make HIIT a valuable tool in combating obesity and promoting sustainable weight management.

Maximal oxygen uptake (VO$_2$max) is a critical indicator of cardiovascular fitness [13]. It reflects

the body's capacity to utilize oxygen during intense physical activity, closely linking it to aerobic fitness [14]. A higher VO₂max is associated with reduced risks of cardiometabolic disorders, including hypertension, dyslipidemia, and type 2 diabetes [15, 16, 17]. Conversely, low VO₂max levels are predictive of increased morbidity and mortality related to non-communicable diseases [16]. Enhancing VO₂max and improving body composition through structured exercise, such as HIIT, has garnered significant research interest.

The analysis of research findings has shown that obesity is a significant global health issue affecting all age groups, including students. High-intensity interval training (HIIT) has proven to be an effective and time-efficient method for improving cardiovascular fitness and managing body composition. HIIT enhances VO₂max, improves metabolic efficiency, and preserves lean muscle mass, making it a valuable tool for combating obesity and reducing associated health risks. Accordingly, this study aims to investigate the effects of progressive 3 by 3 cycling interval training on cardiovascular fitness and body composition in overweight undergraduates.

Materials and Methods

Participants

A priori power analysis for sample size estimation was performed using G*Power version 3.1.9.7, specifying a two-tailed t-test for dependent means (matched pairs) with an effect size of 0.80, an alpha level of 0.05, and a power of 0.80. This analysis determined a required sample size of 15 participants. Consequently, 15 overweight undergraduate students (9 males and 6 females) were recruited, with an average age of 20.2 ± 0.7 years, body weight of 78.2 ± 16.2 kg, BMI of 27.2 ± 3.7 kg/m², and height of 168.9 ± 8.0 cm. Eligibility criteria ensured that participants were free of functional limitations and had no history of medical conditions that would restrict high-intensity exercise. A registered physician conducted general health screenings, and informed written consent was obtained from all participants prior to the study.

All participants were provided with comprehensive information regarding the study procedures, potential benefits, and associated risks, and gave written informed consent prior to participation. The study protocol was approved by the Research and Innovation Administration of Burapha University Ethics Committee (Code: IRB1-107/2562) and adhered to the ethical principles outlined in the Declaration of Helsinki.

Research Design

This study utilized a single-group experimental design to evaluate the effects of cycling interval training on cardiovascular fitness and body composition in overweight undergraduate students. The participants consisted of young, overweight male and female undergraduates from the Faculty of Sport Science, with a body mass index (BMI) of ⩾ 25 kg/m². Cardiovascular fitness was assessed using maximum oxygen consumption (VO₂max), and body composition was measured via bioelectrical impedance analysis, both pre-intervention and post-intervention. The participants underwent 8 weeks of cycling interval training, with a frequency of 3 sessions per week (Figure 1).

Body Composition Measurement

Body weight, body fat percentage, fat mass, and visceral fat were measured using bioelectrical impedance analysis (X-contact 356; Jawon Medical Co., Seoul, South Korea). To ensure consistency, participants were instructed to adhere to specific pre-assessment guidelines, including fasting from food and beverages (except water) for at least 6 hours prior to measurement, abstaining from alcohol and caffeine for 24 hours, and avoiding vigorous physical activity for 48 hours. Additionally, participants were required to obtain a minimum of 6 hours of sleep the night before the assessment to reduce variability caused by fatigue or dehydration. Measurements were conducted in the physiology laboratory at 8:00 a.m. to control for diurnal variations in body composition metrics. Assessments took place three days prior to the start of the experiment and three days after the final training session to ensure consistency in timing. Participants wore lightweight, comfortable
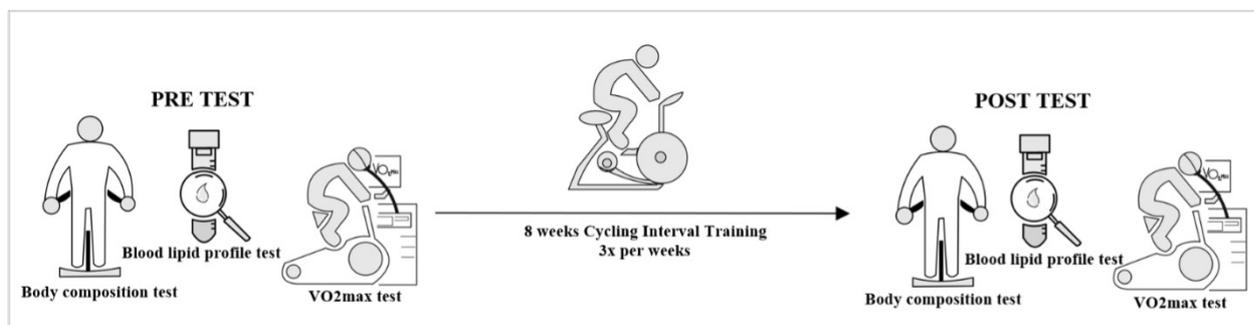

Figure 1. Study design.

clothing and removed all metal accessories during the measurement to prevent interference with the bioelectrical impedance device.

Blood lipid profile Test

A blood lipid profile test was conducted to evaluate participants' total cholesterol, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) levels as indicators of health status. Blood samples were collected in the morning at approximately 9:00 a.m., following body composition measurements, in the university hospital's physiology laboratory. The assessments were performed three days prior to the start of the experiment and three days after the final training session. Participants were instructed to fast for at least six hours and refrain from exercise for 24 hours before testing. A 5 ml blood sample was drawn from each participant, and the analyses were conducted at the university hospital's pathology laboratory.

Maximum oxygen consumption assessment

On the same day, following the laboratory blood lipid profile test, maximum oxygen consumption (VO_2max) was assessed at approximately 11:00 a.m. using an incremental exercise protocol on a manually adjustable bicycle ergometer (Monark 828E, Sweden). The VO_2max test began with a 3-minute warm-up at a workload of 25 watts, followed by an increase in resistance by 25 watts each minute. Participants continued the test until they reached voluntary exhaustion due to fatigue. Oxygen consumption was continuously monitored using a breath-by-breath portable system (Oxycon Mobile, Hoechberg, Germany), and data were recorded every 30 seconds. The highest recorded 30-second oxygen consumption value was documented as the VO_2max. This VO_2max testing protocol adhered to the methodology described in a previously published study [18].

Cycling Interval Training

The cycling interval training was conducted on a stationary sprint bike (IC7 Indoor Cycle, Life Fitness, USA) and followed a protocol alternating between high-intensity intervals at 80–85% of heart rate reserve (HRR) and recovery periods at 50% HRR. HRR for each participant was calculated using Karvonen's formula (HRR = HRmax - HRrest). Heart rate was continuously monitored during each session with a heart rate monitor (H10, Polar, Finland). Participants trained in the morning three times per week over eight weeks, with session duration increasing progressively. In weeks 1–2, participants completed five sets of 3-minute intervals, totaling 30 minutes per session. This duration increased to six sets (36 minutes) in weeks 3–4, seven sets (42

minutes) in weeks 5–6, and eight sets (48 minutes) in weeks 7–8 (Table 1).

Table 1. Cycling Interval Training

Intensity	Interval: 80 – 85%HRR Recovery: 50% HRR
Frequency	3 sessions per week
Cycling Interval Training Protocol High intensity cycling : Recovery time x Numbers of sets (Total duration)	Week 1-2: 3:3 min x 5 sets (30minutes)
	Week 3-4: 3:3 min x 6 sets (36minutes)
	Week 5-6: 3:3 min x 7 sets (42minutes)
	Week 7-8: 3:3 min x 8 sets (48minutes)

Statistical analysis

The Shapiro-Wilk test was applied to assess data normality, and descriptive statistics were calculated to determine the mean and standard deviation of participants' baseline characteristics. A one-way ANOVA was used to compare participants' VO_2max, body composition metrics (body weight, body fat percentage, fat mass, and visceral fat), and blood test variables (LDL-C, HDL-C, and total cholesterol) between pre-intervention and post-intervention. Results were reported with changes and 95% confidence intervals (95% CI). Additionally, Cohen's effect sizes were calculated using the formula: mean change/pooled standard deviation. Effect sizes were interpreted as follows: 0.00–0.19 (Trivial), 0.20–0.49 (Small), 0.50–0.79 (Moderate), and ≥0.80 (Large), in accordance with Cohen's criteria [19]. All statistical analyses were conducted using IBM SPSS Statistics version 21, with the significance level set at $\alpha = 0.05$.

Results

There was no significant difference in body composition parameters (all p > 0.05, all ES = Trivial) or blood lipid profile measurements (all p > 0.05, all ES = Trivial) between pre-intervention and post-intervention (Table 2). In contrast, VO_2max demonstrated a significant improvement following the 8-week intervention, with a mean increase of 4.76 ml·kg^{-1}·min^{-1} (Δ16.24%, 95% CI = 1.27–8.25 ml·kg^{-1}·min^{-1}, ES = Moderate, p = 0.011) (Figure 2).

The effect sizes of the changes observed in each parameter are illustrated in Figure 3, providing a visual representation of the magnitude of these effects and facilitating clearer interpretation of the intervention's impact.

Table 2. Changes in measurements between Pre- and Post-intervention

Measurement	Participants (n = 15)		Change (CI95%)
	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	
Body weight (kg)	78.17 ± 4.18	77.81 ± 4.33	-0.37 (1.21; 0.47)
BMI (kg/m^2)	27.15 ± 0.96	27.02 ± 1.04	-0.13 (-0.44; 0.18)
Body fat (%)	29.27 ± 1.37	29.01 ± 1.45	-0.27 (-0.79; 0.26)
Fat mass (kg)	23.83 ± 1.91	22.89 ± 2.08	-0.94 (-2.53; 0.65)
Visceral fat (cm^2)	83.53 ± 7.57	81.73 ± 7.38	-1.80 (-3.77; 0.17)
VO$_2$max (ml/kg^{-1}/min^{-1})	29.31 ± 1.26	34.07 ± 1.94*	4.76 (1.27; 8.25)
Total cholesterol (mg/dl^{-1})	193.73 ± 10.89	190.47 ± 8.98	-3.27 (-12.98; 6.45)
LDL-C (mg/dl^{-1})	115.53 ± 10.18	112.40 ± 8.44	-3.13 (-15.67; 9.70)
HDL-C (mg/dl^{-1})	55.80 ± 2.49	54.80 ± 1.97	-1.00 (-5.21; 3.21)

Abbreviations: BMI = body mass index; LDL-C = low-density lipoprotein cholesterol; HDL-C = high-density lipoprotein cholesterol; VO$_2$max = maximum oxygen consumption. * indicated significant different from Pre-intervention (p < 0.05)
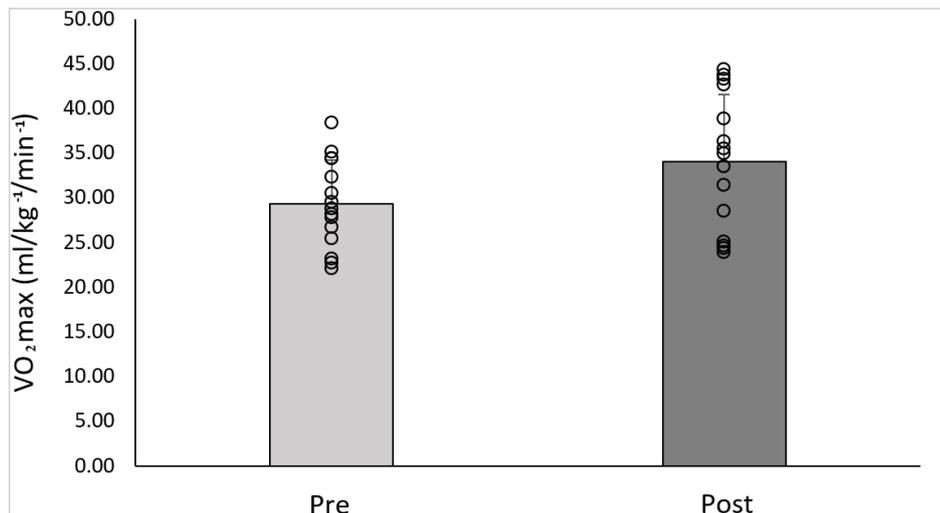
Figure 2. Means and standard deviations of maximum oxygen consumption (VO$_2$max) at pre-intervention and post-intervention, with individual analyses in open circle. * indicating significant different from pre-intervention (p < 0.05).
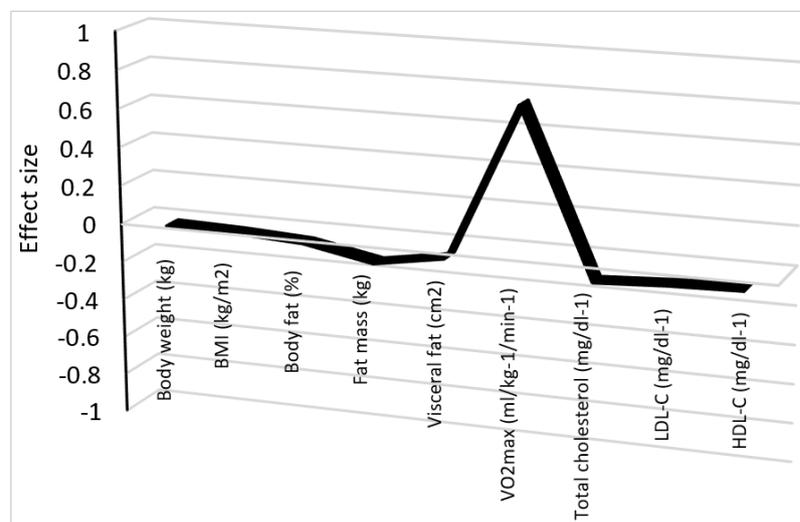
Figure 3. Cohen's effect sizes of each parameter.

Discussion

The findings of this study emphasized the potential of progressive cycling interval training to significantly enhance cardiovascular fitness, as reflected by an improvement in VO_2max. This outcome aligns with existing literature identifying certain types of HIIT as an alternative modality to steady-state exercise for improving aerobic capacity [20, 21, 22, 23]. The 16.24% improvement in VO_2max observed in this study demonstrates the effectiveness of structured progressive 3 by 3 cycling interval training protocols, even in overweight individuals. This increase in VO_2max is potentially associated with reduced cardiovascular risks and improved metabolic health [24], making it a critical target for intervention strategies in populations at risk of obesity-related comorbidities [10].

The absolute improvement in VO_2max in this study was 4.76 $ml·kg^{-1}·min^{-1}$, or approximately 0.28 $l·min^{-1}$ (ES = 0.75). This level of improvement is consistent with findings from a previous meta-analysis, which reported a mean VO_2max increase of 0.26 $l·min^{-1}$ (ES = 0.68) when interval training was performed at an intensity of 80–92.5% [25]. These results collectively suggest that the capacity for VO_2max improvement might not differ significantly between overweight and normal-weight healthy individuals. Furthermore, prior research demonstrated that VO_2max trainability in healthy individuals could reach up to 0.43–0.60 $l·min^{-1}$ with training durations of 6 to 12 weeks [26]. This suggests that participants in the current study could achieve even greater VO_2max improvements if training were continued.

Despite the improvement in cardiovascular fitness, this study found no significant changes in body composition, including body weight, body fat percentage, or visceral fat (all p > 0.05). This finding challenges the commonly held assumption that HIIT is an effective standalone strategy for body weight or fat loss [27]. Similarly, previous research employing a battle rope HIIT protocol reported a significant increase in VO_2max by 3.68 $ml·kg^{-1}·min^{-1}$ but found no significant changes in participants' body composition [13]. Additionally, a previous study reported that participants undergoing resistance training without caloric restriction also failed to achieve body weight reduction [28].

Taken together, these findings highlight the importance of energy balance in achieving body composition changes, emphasizing that caloric intake must align with expenditure for fat loss to occur [29]. The absence of dietary control in this study likely contributed to the unchanged body composition, as participants might have compensated for the energy expenditure during exercise by increasing caloric intake [30]. Therefore, the findings underscore the need for combined interventions incorporating both structured exercise and dietary modifications to achieve meaningful changes in body composition.

Moreover, the lack of improvement in the blood lipid profile also warrants consideration. While aerobic exercise is generally associated with improved lipid metabolism [31], our results demonstrated no significant differences post-intervention. It is possible that the duration of this study's intervention was not sufficiently long to elicit measurable changes in this parameter among overweight individuals. Additionally, the trivial effect sizes suggest that more prolonged or higher-intensity training programs might be necessary to significantly influence lipid profiles [10]. Another potential factor is the variability in participants' baseline lipid levels, which might have masked subtle improvements.

In practical terms, this study contributes to the growing body of evidence supporting HIIT as an efficient exercise modality, particularly for improving cardiovascular fitness in time-constrained individuals [32]. The intentional progressive design of the protocol, which gradually increased session duration, likely enhanced adherence and minimized the risk of participant overtraining [33].

Moreover, the findings underscore the importance of tailoring interventions to specific health goals. Progressive cycling interval training proved highly effective for improving cardiovascular fitness; however, for individuals targeting fat loss or metabolic health, combining such protocols with dietary adjustments and other lifestyle changes may yield better outcomes.

Study Limitation

The single-group design of this study limits the generalizability of its findings, as there was no comparison group to assess the relative effectiveness of this protocol against alternative exercise modalities. Additionally, the small sample size and narrow demographic scope restrict the applicability of the results to broader populations.

Future research involving larger, more diverse cohorts and a comparative approach would provide more comprehensive insights. Such studies could also help practitioners manage expectations, emphasizing that no single exercise modality delivers immediate or universal benefits across all health parameters.

Conclusions

This study demonstrated that progressive 3 by 3 cycling interval training is an effective intervention for enhancing cardiovascular fitness in overweight individuals, as evidenced by a significant increase in VO_2max. However, its limited impact on body

composition and blood lipid profiles suggests that HIIT alone may not suffice for comprehensive health improvements. These findings reinforce the importance of a multifaceted approach to obesity management, combining exercise, nutrition, and behavioral strategies to optimize health outcomes.

Conflict of Interest

The authors declare no conflict of interest.

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