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Aerobic Interval Training on Fitness and Academic Motivation in Overweight Female Students: Randomized Controlled Trial

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Abstract

Background: Overweight and obesity among young adults are associated with reduced aerobic fitness and academic motivation. Sedentary lifestyles may further exacerbate these problems among university students.

Objective: This study aimed to determine the effects of Aerobic Interval Training (AIT) on aerobic fitness and academic motivation in overweight female university students.

Methods: A single blinded randomized controlled trial included 30 overweight female university students aged 18 to 28 years with a BMI of 23 to 30 kg/m². Participants were recruited using quota sampling and randomly allocated to an AIT group or an education only control group. The AIT group performed training three times weekly for 12 weeks at 70% to 80% HRmax, while controls received physical activity and dietary education. Aerobic fitness was assessed using the Cooper 12-minute test, and academic motivation was measured using the Academic Motivation Scale. Data were analyzed using appropriate parametric or nonparametric tests, with effect sizes and 95% confidence intervals calculated.

Results: The AIT group showed a significant improvement in VO_2max compared with controls, with a mean change of 13.85 ml/kg/min (95% CI: 7.88 to 13.77; Cohen's d = 2.75; $p < 0.001$). The control group showed decreased aerobic capacity. Significant improvements were also found in intrinsic motivation toward achievement and learning satisfaction ($p < 0.05$).

Conclusion: Twelve weeks of AIT significantly improved aerobic fitness and academic motivation in overweight female university students.

Keywords
Aerobic interval training; aerobic fitness; academic motivation; overweight; university students

Introduction

Overweight and obesity result from an imbalance between energy intake and energy expenditure, leading to excessive adipose tissue accumulation and increased cardiometabolic risk. According to the World Health Organization, obesity has become a global public health epidemic driven by rapid lifestyle transitions, increased consumption of energy-dense foods, urbanization, and reduced physical activity. Recent estimates indicate that more than one billion individuals worldwide are affected by overweight or obesity, including a substantial proportion of young adults, a population particularly vulnerable to sedentary behaviors during the transition to university life.[1–4]

In young adults, excess body weight is consistently associated with reduced aerobic fitness, impaired cardiorespiratory efficiency, and adverse psychological outcomes, including lower self-esteem, increased anxiety, and diminished motivation to engage in academic activities.[5] University students face unique environmental and behavioral challenges, such as high academic demands, irregular schedules, and limited time availability, which frequently lead to reduced physical activity participation and declining fitness levels during early adulthood.[6,7] These factors make university students an important target population for structured exercise interventions evaluated using rigorous experimental designs.

Aerobic exercise is widely recognized as an effective strategy for improving cardiorespiratory fitness and metabolic health. Among various exercise modalities, Aerobic Interval Training (AIT), a structured form of high-intensity interval training, has gained increasing attention due to its time efficiency and strong physiological benefits. AIT typically consists of repeated bouts of vigorous-intensity exercise interspersed with short recovery periods, allowing participants to achieve substantial improvements in maximal oxygen uptake (VO_2max) within relatively short training durations. Evidence from controlled trials indicates that interval-based aerobic exercise elicits greater improvements in VO_2max compared with moderate continuous training, particularly in overweight and obese populations.[8–14]

Beyond its physiological effects, growing evidence suggests that exercise may exert meaningful influences on cognitive and psychological outcomes. Physical activity has been shown to enhance executive function, mood regulation, and reward processing through neurobiological mechanisms involving increased cerebral blood flow, neurotrophic factor release, and modulation of neurotransmitter systems.[14,15] These adaptations are thought to support higher levels of intrinsic motivation, persistence, and engagement in learning-related activities. Classroom- and university-based studies have reported that structured physical activity interventions can improve academic motivation and learning engagement, even in the absence of direct academic instruction.[16]

Importantly, despite the expanding literature on high-intensity and interval-based exercise, there remains limited randomized controlled trial evidence specifically examining the effects of Aerobic Interval Training on academic motivation in overweight university students. Existing studies often employ observational designs, short intervention periods, or heterogeneous exercise protocols, limiting causal inference and practical applicability.[17–20] Furthermore, most studies linking aerobic fitness with academic outcomes have focused on children or adolescents, emphasizing academic performance or cognitive mediators rather than motivation as a primary outcome.[21,22]

This gap in the literature highlights the need for a well-designed randomized controlled trial to evaluate whether a structured Aerobic Interval Training program can produce clinically meaningful improvements in both aerobic fitness and academic motivation in overweight female university students. A randomized controlled design is particularly warranted to isolate the effects of AIT from confounding behavioral and environmental factors commonly present in university settings.

Therefore, the primary objective of this randomized controlled trial was to determine the effects of a 12-week Aerobic Interval Training program on aerobic fitness, as measured by VO_2max, in overweight female university students. The secondary objective was to evaluate the effects of AIT on academic motivation across multiple domains measured using the Academic Motivation Scale. It was hypothesized that participants receiving AIT would demonstrate significantly greater improvements in aerobic fitness and academic motivation compared with those receiving education alone.

Methods

This study was conducted as a single-blinded, two-arm randomized controlled trial in accordance with the CONSORT guidelines for randomized trials. The trial was designed to evaluate the causal effects of Aerobic Interval Training (AIT) on aerobic fitness and academic motivation. Ethical approval was obtained from the Research Health Ethics Commission (KEKP) of the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta (No. 623/KEPK-FIK/XI/2024), and the study was registered in the Thai Clinical Trials Registry (TCTR20250802002). Written informed consent was obtained from all participants prior to enrollment.

The study population consisted of overweight female university students enrolled at Universitas Muhammadiyah Surakarta. Participants were initially recruited using a non-probability quota sampling technique to ensure adequate representation of eligible overweight female students. Randomization was performed after quota-based recruitment and baseline assessment to maintain internal validity consistent with randomized controlled trial methodology.

Inclusion criteria were women aged 18–28 years with a body mass index (BMI) of 23–30 kg/m², no history of respiratory disorders or musculoskeletal injuries limiting exercise participation, and willingness to complete the intervention. Exclusion criteria included pregnancy, cognitive impairment, BMI <23 kg/m² or >30 kg/m², excessive physical stress, or inability to attend intervention sessions consistently.

The sample size was calculated using G*Power version 3.1.9.4 with an assumed effect size of 1.6, α error probability of 0.05, and statistical power of 95% for a two-tailed test. After accounting for an anticipated attrition rate of 20%, a total sample size of 30 participants (15 per group) was determined to be sufficient to detect clinically meaningful differences between groups.

Participants who met the eligibility criteria and completed baseline assessments were randomly assigned to either the AIT intervention group (Group A) or the control group (Group B) using a computer-generated random number sequence. The randomization sequence was generated by an independent researcher not involved in recruitment or assessment. Allocation concealment was achieved using sealed opaque envelopes, which were opened only after baseline measurements were completed. Outcome assessors and data analysts were blinded to group allocation, while intervention providers were not blinded due to the nature of the exercise intervention.

The intervention period consisted of 12 weeks of Aerobic Interval Training, followed by a 4-week non-intervention follow-up period used exclusively for final evaluation. This distinction clarifies that the active intervention duration was 12 weeks, while the total study duration was 16 weeks.

Group A participated in supervised AIT sessions three times per week. Each session followed a standardized structure consisting of a warm-up phase, interval exercise phase, and cool-down phase. Exercise intensity was progressively increased every four weeks from 70% to 80% of maximum heart rate (HRmax), monitored using heart rate monitoring and the validated talk test for vigorous intensity exercise.[23]

Each session included a 30-second warm-up, followed by 45 seconds of active exercise and 15 seconds of recovery intervals, and concluded with a 30-second cool-down, with total session duration progressing from 30 to 40 minutes across the intervention period. The control group received structured educational sessions on physical activity and diet, including counseling and instructional materials, without supervised exercise participation.

Aerobic fitness was assessed using the Cooper 12-minute running test, which estimates maximal oxygen uptake (VO_2max). The Cooper test has demonstrated acceptable validity and reliability for estimating aerobic capacity in young adults and has been widely used in exercise intervention studies.[9,10] Academic motivation was measured using the Academic Motivation Scale (AMS), which evaluates intrinsic motivation, extrinsic motivation, and amotivation across seven domains. The AMS has been shown to possess good psychometric properties, including construct

Data were analyzed using SPSS software. Normality of data distribution was assessed using the Shapiro–Wilk test. For normally distributed data, repeated measures analysis of variance (Repeated Measures ANOVA) was used to evaluate within-group changes, while the Friedman test was applied for non-normally distributed variables. Between-group comparisons were performed using independent t-tests or Mann–Whitney U tests as appropriate. Effect sizes (Cohen's d) and 95% confidence intervals were calculated to quantify the magnitude of intervention effects. Statistical significance was set at $p < 0.05$.

Results

Participant recruitment and study flow are presented in Figure 1. A total of 42 participants were assessed for eligibility, of whom 12 were excluded because they did not meet the inclusion criteria (n = 7) or declined to participate (n = 5). The remaining 30 eligible participants were randomly allocated equally to the Aerobic Interval Training (AIT) group (n = 15) and the education only control group (n = 15). All participants received their allocated intervention and completed the 12-week intervention period. No participants were lost to follow up, and all 30 participants were included in the final analysis.

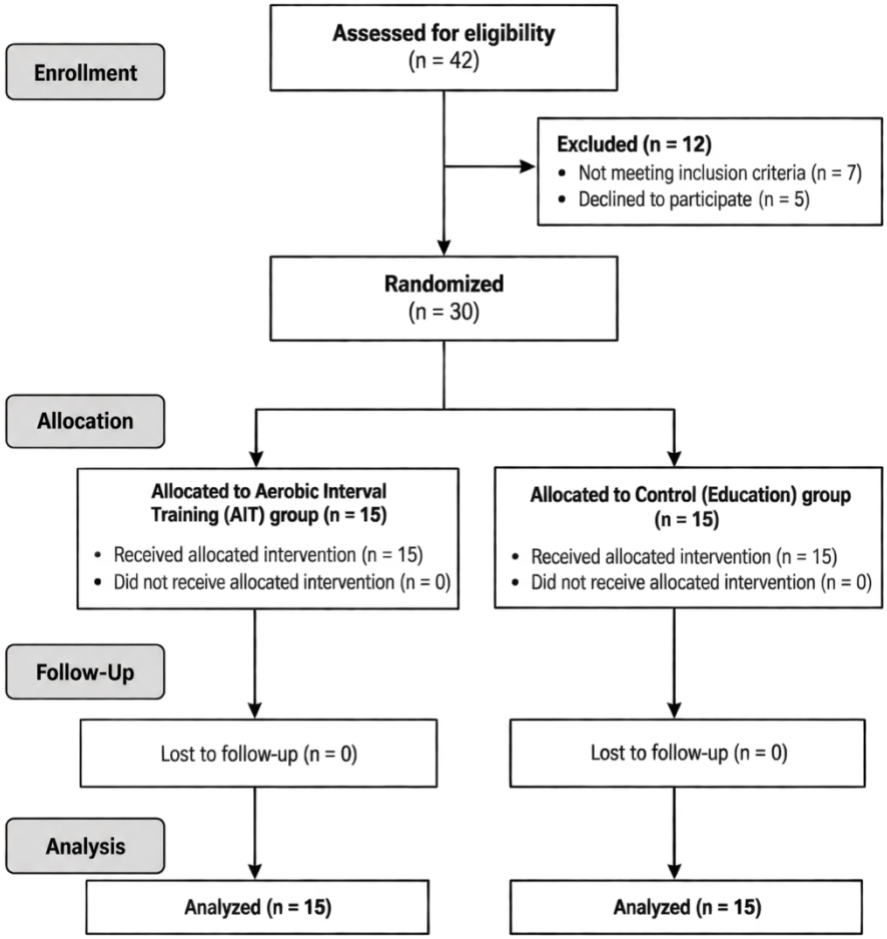

Figure 1. CONSORT Flow Diagram of Participant Recruitment, Randomization, Follow Up, and Analysis

Table 1. Baseline Demographic and Clinical Characteristics of Participants (n = 30)

Variable	AIT Group (n = 15) Mean ± SD	Control Group (n = 15) Mean ± SD	p-value
Age (years)	19.26 ± 0.88	19.46 ± 0.74	>0.05
BMI (kg/m²)	28.59 ± 2.17	27.93 ± 2.75	>0.05
VO_2max (ml/kg/min)	13.57 ± 2.30	12.50 ± 2.55	0.446
AMS Domain 1	25.40 ± 2.09	25.33 ± 2.63	0.449
AMS Domain 2	21.73 ± 2.25	23.06 ± 2.98	0.126
AMS Domain 3	21.80 ± 3.72	23.20 ± 3.27	0.823
AMS Domain 4	25.53 ± 2.53	25.35 ± 2.49	0.791
AMS Domain 5	20.80 ± 2.95	22.93 ± 3.34	0.476
AMS Domain 6	24.13 ± 3.44	24.73 ± 2.98	0.611
AMS Domain 7	21.40 ± 2.69	23.20 ± 3.12	0.371

At baseline, VO_2max values in both groups were classified as very low according to age-specific normative references, reflecting the overweight status and predominantly sedentary lifestyle of the participants. This finding is consistent with previous reports in young adult women with limited physical activity exposure.

Following the intervention, the AIT group demonstrated a marked and statistically significant increase in VO_2max, improving from 13.57 ± 2.30 ml/kg/min to 27.42 ± 5.08 ml/kg/min ($p < 0.001$). This represents a substantial enhancement in aerobic capacity and cardiorespiratory fitness.

In contrast, the control group showed a significant decline in VO_2max, decreasing from 24.86 ± 2.50 ml/kg/min to 15.52 ± 3.52 ml/kg/min ($p = 0.002$). This reduction is likely attributable to physical deconditioning associated with the absence of structured exercise during the study period, a phenomenon commonly observed in inactive young adults.Between-group analysis confirmed a large and clinically meaningful intervention effect, with a mean difference of 10.83 ml/kg/min (95% CI: 7.88–13.77) and a very large effect size (Cohen's $d = 2.75$; $p < 0.001$).

All seven domains of academic motivation showed statistically significant within-group improvements in the AIT group after the 12-week intervention ($p < 0.05$). The most pronounced improvements were observed in intrinsic motivation toward achievement (Domain 2) and intrinsic motivation to experience stimulation (Domain 3), indicating enhanced internal engagement and learning satisfaction.

In contrast, the control group demonstrated minimal or non-significant changes across most academic motivation domains. Only slight improvements were observed in Domains 3 and 7, while other domains showed no meaningful changes.

Between-group comparisons revealed that AIT produced significantly greater improvements than education alone, particularly in intrinsic motivation domains, with large effect sizes (Cohen's $d > 2.0$) observed in Domains 2, 3, and 5. These findings identify intrinsic academic motivation as the most responsive psychological outcome to Aerobic Interval Training.

Table 2. Within-Group Changes in Aerobic Fitness and Academic Motivation (Pre–Post Intervention)

Outcome	AIT Group (n = 15) Mean ± SD	p-value	Control Group (n = 15) Mean ± SD	p-value
VO_2max (ml/kg/min)	13.57 ± 2.30 → 27.42 ± 5.08	<0.001	24.86 ± 2.50 → 15.52 ± 3.52	0.002
AMS Domain 1	25.40 ± 2.09 → 27.26 ± 0.88	<0.001	25.33 ± 2.63 → 27.40 ± 0.82	0.002
AMS Domain 2	21.73 ± 2.25 → 26.06 ± 1.53	<0.001	23.06 ± 2.98 → 25.33 ± 2.63	0.368
AMS Domain 3	21.80 ± 3.72 → 26.46 ± 1.30	<0.001	23.20 ± 3.27 → 23.40 ± 2.89	0.018
AMS Domain 4	25.53 ± 2.53 → 26.46 ± 1.30	0.012	25.73 ± 2.49 → 23.53 ± 3.02	0.368
AMS Domain 5	20.80 ± 2.95 → 26.46 ± 1.30	<0.001	22.93 ± 3.34 → 25.80 ± 2.36	>0.05
AMS Domain 6	24.13 ± 3.44 → 26.33 ± 2.02	<0.001	24.73 ± 2.98 → 22.93 ± 3.34	0.135
AMS Domain 7	21.40 ± 2.69 → 25.46 ± 1.84	<0.001	23.20 ± 3.12 → 25.33 ± 2.49	0.005

Table 3. Between-Group Effect Sizes for Aerobic Fitness and Academic Motivation (Post-Intervention)

Outcome	Mean Difference	95% CI	Cohen's d	p-value
VO_2max (ml/kg/min)	10.83	7.88 – 13.77	2.75	<0.001
AMS Domain 1	−0.20	−1.77 – 1.37	–	0.712
AMS Domain 2	4.00	2.88 – 5.12	2.67	<0.001
AMS Domain 3	3.33	2.18 – 4.49	2.16	<0.001
AMS Domain 4	0.87	−0.13 – 1.86	0.65	0.031
AMS Domain 5	5.07	3.62 – 6.51	2.62	<0.001
AMS Domain 6	1.60	0.09 – 3.11	0.79	0.033
AMS Domain 7	2.40	0.46 – 4.34	0.93	0.017

Discussion

The present randomized controlled trial demonstrated that a 12-week Aerobic Interval Training (AIT) program produced substantial improvements in aerobic fitness and academic motivation among overweight female university students, with effects that were significantly greater than education alone. These findings confirm the clinical efficacy of AIT as a time-efficient intervention to enhance cardiorespiratory capacity in sedentary young adults, while also providing evidence for its educational relevance through improvements in learning motivation.

The marked increase in VO_2max observed in the AIT group represents a clinically meaningful improvement in aerobic capacity, consistent with prior interval-training studies conducted in overweight and obese young women.[13,14] Interval-based exercise is known to elicit superior central and peripheral cardiovascular adaptations compared with moderate continuous training, including enhanced stroke volume, improved oxygen delivery, and increased skeletal muscle oxidative capacity.[10,23] From a clinical perspective, such improvements are particularly relevant for overweight individuals, who typically present with low baseline aerobic fitness and elevated cardiometabolic risk.[17–20]

In contrast, the decline in VO_2max observed in the control group highlights the negative impact of physical inactivity and the insufficiency of education-only approaches. This pattern is consistent with previous randomized trials demonstrating that health education alone fails to prevent aerobic deconditioning in sedentary populations, particularly when academic demands and sedentary behaviors dominate daily routines.[7,24] These findings underscore the necessity of structured, supervised exercise interventions to induce and maintain physiological adaptations.

Beyond aerobic fitness, AIT produced significant improvements across multiple domains of academic motivation, with the largest effects observed in intrinsic motivation toward achievement and learning satisfaction. These results align with growing evidence that physical activity positively influences psychological constructs related to engagement, persistence, and self-regulation in educational contexts.[16] Unlike extrinsic incentives, intrinsic motivation is strongly associated with sustained learning behaviors and academic success, making it a critical outcome for university-based interventions.[21,22]

Recent randomized controlled trials conducted between 2023 and 2025 further support the positive role of structured physical activity interventions in enhancing academic motivation among university students, demonstrating improvements in intrinsic motivation, engagement, and self-regulated learning.

The educational implications of these findings are noteworthy. Regular participation in structured AIT may enhance students' motivation to engage in learning activities by fostering mastery experiences, improving mood regulation, and increasing perceived competence. Prior studies suggest that physical activity supports motivational processes through improved executive control, reward sensitivity, and emotional regulation.[14,25] From an applied perspective, integrating AIT into campus wellness or physiotherapy-led health promotion programs may provide dual benefits for physical health and learning motivation among overweight students.

Although molecular mechanisms such as PGC-1α activation, mitochondrial biogenesis, and neurotrophic factor release have been widely reported in the literature,[26–29] the present study primarily emphasizes clinically observable and educationally relevant outcomes rather than mechanistic pathways. This focus aligns with the applied nature of the intervention and the study's randomized clinical design. Future mechanistic investigations may further elucidate the biological pathways underlying the observed motivational improvements.

Several methodological limitations should be acknowledged. First, the study included only female participants, limiting the generalizability of findings to male students. Second, academic motivation was assessed using a self-reported instrument, which may be subject to response bias. Third, although outcome assessors were blinded, intervention providers could not be blinded due to the nature of the exercise protocol. Additionally, the relatively short intervention duration precludes conclusions regarding long-term sustainability of the observed effects. These limitations are consistent with those reported in similar exercise-based randomized trials.[14,30]

Despite these limitations, the study possesses several strengths, including a randomized controlled design, standardized intervention protocol, high adherence, and the simultaneous evaluation of physiological and educational outcomes. Taken together, the findings provide robust evidence supporting the integration of Aerobic Interval Training into university-based health and fitness programs targeting overweight young adults.

Conclusion

This randomized controlled trial demonstrated that a structured 12-week Aerobic Interval Training (AIT) program produced significant improvements in aerobic fitness and academic motivation among overweight female university students. The most pronounced effects were observed in maximal oxygen uptake (VO_2max) and intrinsic domains of academic motivation, particularly motivation toward achievement and learning satisfaction. These findings indicate that AIT is an effective and time-efficient intervention for enhancing both physiological capacity and motivational engagement in sedentary young adults.

Importantly, the outcomes of this study were limited to academic motivation rather than direct indicators of academic achievement. Therefore, conclusions regarding academic performance should be interpreted with caution, as objective academic outcomes were not measured. Nonetheless, previous evidence suggests that improvements in aerobic fitness and intrinsic motivation may indirectly support learning engagement and persistence, which are critical components of academic success.

From a clinical perspective, the substantial increase in VO_2max highlights the potential of AIT to address low aerobic fitness commonly observed in overweight university students, a group at increased risk of future cardiometabolic disorders. From an educational and public health perspective, integrating structured AIT programs into university-based physiotherapy services or campus wellness initiatives may provide dual benefits by promoting physical health and fostering learning motivation.

Overall, Aerobic Interval Training represents a feasible, evidence-based strategy that can be implemented within university settings to support both physical well-being and academic motivation among overweight female students. Future randomized controlled trials incorporating longer follow-up periods, mixed-sex samples, and objective academic outcomes are warranted to further clarify the long-term educational impact of Aerobic Interval Training.

Author Contribution

Risma Salsabila Isnaini Putri: Conceptualization, Writing review and editing.
Farid Rahman: Data curation, Writing original draft.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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Ethics Statement

This study was approved by the Research Health Ethics Commission (KEKP) of the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta (Approval No. 623/KEPK-FIK/XI/2024). Written informed consent was obtained from all participants prior to study participation.

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