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High-intensity interval training versus moderate-intensity continuous training on cardiovascular fitness and body composition in sedentary young adults: A 12-week randomized controlled trial

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Abstract
Background: Non-communicable diseases linked to sedentary lifestyles represent a global public health burden. High-intensity interval training (HIIT) has been proposed as a time-efficient alternative to traditional moderate-intensity continuous training (MICT) for improving cardiovascular fitness and body composition; however, comparative evidence in sedentary young adult populations is incomplete.

Objective: To compare the effects of 12-week HIIT versus MICT programmes on VO_2max, resting heart rate, body mass index (BMI), and waist circumference in sedentary young adults.

Method: A three-arm randomized controlled trial assigned 90 sedentary adults (18–30 years; 48 female, 42 male) to HIIT ($n = 30$), MICT ($n = 30$), or a no-exercise control group ($n = 30$). Exercise sessions were three times per week, with HIIT sessions lasting 20 minutes and MICT sessions lasting 45 minutes. VO_2max was assessed by incremental treadmill ergometry; body composition by DEXA scan. SPSS v.28 was used for ANCOVA analysis. This study uses a simulated dataset created for academic training purposes.

Key Results: HIIT produced significantly greater VO_2max improvements than MICT (Δ+5.8 vs. Δ+3.9 mL/kg/min; $p = 0.031$) with less total exercise time (240 vs. 540 min/month). Both exercise groups significantly reduced BMI and waist circumference compared to controls ($p < 0.01$), with no significant difference between HIIT and MICT for body composition outcomes.

Conclusion: HIIT is more time-efficient than MICT for improving cardiorespiratory fitness in sedentary young adults and produces equivalent body composition improvements, supporting its utility in public health exercise promotion.

Keywords: VO_2max, exercise physiology, body composition, sedentary adults, cardiovascular fitness

Introduction
Physical inactivity has been identified by the World Health Organization as the fourth leading risk factor for global mortality, directly associated with non-communicable diseases including type 2 diabetes mellitus, cardiovascular disease, and certain cancers [1]. Young adults (18–30 years) represent a particularly vulnerable population segment: epidemiological data indicate declining physical activity participation through late adolescence and early adulthood, with sedentary behaviour compounded by academic and occupational demands, digital media consumption, and urbanization-associated lifestyle factors [2].

Cardiorespiratory fitness, most robustly indexed by maximal oxygen uptake (VO_2max), is among the most powerful independent predictors of all-cause and cardiovascular mortality across the adult lifespan [3]. Conversely, adiposity-related metrics including BMI and waist circumference as markers of central adiposity are independently predictive of cardiometabolic risk. The exercise modality that most efficiently and effectively improves both VO_2max and body composition in the sedentary population is, therefore, of direct public health significance [4].

Moderate-intensity continuous training (MICT), characterized by sustained exercise at 60–75% of maximum heart rate (HRmax) for 30–60 minutes per session, has represented the guideline-recommended exercise prescription for cardiovascular health improvement since the 1970s [5]. However, adherence to MICT is constrained by time demands, and evidence from high-income urban contexts suggests that 'lack of time' is the most commonly cited barrier to exercise participation across adult age groups [6].

High-intensity interval training (HIIT) defined as repeated bouts of exercise at ≥80% HRmax interspersed with recovery periods has emerged as a scientifically validated, time-efficient exercise paradigm [7]. HIIT sessions typically require 15–25 minutes of total exercise time (versus 40–60 minutes for comparable MICT sessions), and meta-analytic evidence suggests superior or equivalent improvements in VO_2max relative to MICT across diverse populations [8]. However, the evidence specifically within sedentary young adult cohorts is less extensive, and concerns persist regarding the safety and tolerability of HIIT intensities in physically deconditioned individuals [9].

This three-arm RCT was designed to provide definitive comparative evidence on HIIT versus MICT across the complementary outcome domains of cardiorespiratory fitness and body composition in sedentary young adults, with appropriate safety monitoring and an active no-exercise control arm to account for secular change effects [10].

Literature review
The mechanistic basis for HIIT's cardiovascular superiority is rooted in distinct physiological adaptations relative to MICT. HIIT produces greater central cardiac adaptations including increased stroke volume and enhanced cardiac output at maximal exercise through the high cardiac output demands imposed during the intense intervals [11]. Peripheral

adaptations, including skeletal muscle mitochondrial biogenesis mediated by peroxisome proliferator-activated receptor gamma coactivator 1-alpha (PGC-1α) and angiogenesis, are comparably or more robustly stimulated by HIIT than MICT in sedentary individuals [12].

Weston, Wisløff, and Coombes [13] conducted a landmark meta-analysis of 10 head-to-head RCT comparisons of HIIT versus MICT in patients with lifestyle-related chronic disease, reporting significantly greater VO_2max improvements with HIIT (MD = +3.03 mL/kg/min; 95% CI: 2.00–4.07) while noting that both modalities produced similar reductions in metabolic risk factors. These findings were subsequently extended to healthy but sedentary populations by Milanović *et al*. [14], whose meta-analysis of 13 studies reported HIIT superiority for VO_2max improvement (d = 0.58).

The body composition evidence presents a more nuanced picture. Keating *et al* [15]. systematically reviewed 13 RCTs and concluded that neither HIIT nor MICT consistently produced greater total body fat reductions, while noting that HIIT was associated with superior reductions in subcutaneous abdominal fat an outcome with specific cardiometabolic significance beyond total body mass. The mechanistic rationale involves greater post-exercise oxygen consumption (EPOC) and catecholamine-driven lipolysis following HIIT sessions compared to MICT [16].

The adherence and tolerability of HIIT in sedentary populations has been queried in several studies. Surprisingly, Gist *et al* [17]. reported that sedentary participants' enjoyment ratings did not differ significantly between HIIT and MICT programmes, and dropout rates were comparable challenging the assumption that HIIT's perceived difficulty limits its acceptability. However, most HIIT adherence data derive from supervised laboratory settings; real-world adherence in unsupervised contexts may be substantially lower [18].

A specific evidence gap concerns the relative efficacy of HIIT and MICT in sedentary Asian young adults, a population segment characterized by a lower BMI threshold for cardiometabolic risk relative to Western reference populations and by distinct exercise culture, environmental, and motivational factors [19]. The present RCT contributes to this underrepresented literature.

Methodology

1. Research design

A three-arm, parallel-group randomized controlled trial was conducted over 12 weeks with 36-week follow-up planned. Full ethical approval was granted by the institutional research ethics committee.

2. Participants

Ninety sedentary young adults (18–30 years; 48 female, 42 male) were recruited through university notice boards. Sedentariness was defined as <60 minutes of moderate physical activity per week for the preceding three months (verified by International Physical Activity Questionnaire). Exclusion criteria included cardiovascular, pulmonary, or musculoskeletal conditions contraindicating high-intensity exercise; current smoking; and BMI > 35 kg/m [2]. Participants were randomized 1:1:1 to HIIT, MICT, or control groups using a computerized allocation sequence.

3. Exercise protocols

HIIT Protocol: Three sessions per week, each comprising 10 × 1-minute intervals at 85–90% HRmax, separated by 1-minute active recovery at 50% HRmax (total 20 minutes, including 5-minute warm-up and cool-down). MICT Protocol: Three sessions per week, each comprising 35 minutes at 65–70% HRmax (total 45 minutes with 5-minute warm-up and cool-down). Both protocols were conducted on motorized treadmills under investigator supervision. Heart rate was monitored continuously via Polar HR monitors.

4. Outcome measures

Primary: VO_2max (mL/kg/min) assessed via Bruce Protocol incremental treadmill test with metabolic cart at weeks 0 and 12. Secondary: BMI (kg/m [2]), waist circumference (cm) measured by trained assessors; resting heart rate (RHR, bpm) assessed after 10-minute supine rest.

5. Statistical analysis

One-way ANCOVA (controlling for baseline values and sex) was used to compare 12-week outcomes across groups in SPSS v.28. Tukey's HSD post-hoc tests were applied for pairwise comparisons. Cohen's d was computed for between-group effect sizes.

Results and Discussion

Table 1: Baseline participant characteristics across groups

Variable	HIIT (n=30)	MICT (n=30)	Control (n=30)
Age (years)	22.4 ± 3.1	23.1 ± 2.8	22.9 ± 3.4
BMI (kg/m [2])	24.8 ± 3.2	25.1 ± 2.9	24.6 ± 3.1
VO_2max (mL/kg/min)	31.2 ± 5.4	30.8 ± 5.1	31.5 ± 5.6
Waist Circumference (cm)	78.4 ± 8.6	79.1 ± 8.2	78.8 ± 9.0
Resting Heart Rate (bpm)	76.2 ± 8.4	75.8 ± 7.9	76.9 ± 8.1

Source: Simulated training dataset (2026). No significant between-group baseline differences (all p > 0.05).

Table 2: Pre- to post-intervention changes in primary and secondary outcomes

Outcome	HIIT (Δ)	MICT (Δ)	Control (Δ)	HIIT vs MICT p	η^2
VO_2max (mL/kg/min)	+5.8 ± 1.6*	+3.9 ± 1.4*	+0.3 ± 0.9	0.031*	0.34
BMI (kg/m [2])	−1.4 ± 0.6*	−1.3 ± 0.5*	−0.1 ± 0.4	0.714 (ns)	0.19
Waist Circumference (cm)	−3.8 ± 1.5*	−3.5 ± 1.4*	−0.4 ± 0.9	0.621 (ns)	0.22
Resting Heart Rate (bpm)	−8.2 ± 3.1*	−6.1 ± 2.8*	−0.9 ± 2.2	0.046*	0.18

Source: Simulated training dataset (2026). *Significantly different from control ($p < 0.01$). η^2 = partial eta squared.

HIIT produced significantly greater improvements in VO_2max than MICT (Δ+5.8 vs. Δ+3.9 mL/kg/min; $p = 0.031$; $\eta^2 = 0.34$ a large effect size), despite involving less than half the total exercise time commitment (240 vs. 540 minutes over the 12-week period). This finding corroborates meta-analytic benchmarks [20] and strengthens the case for HIIT as a preferred exercise modality in populations where time is a primary barrier to physical activity participation.

Both active exercise groups achieved statistically and clinically meaningful reductions in BMI (approximately −1.3 to −1.4 kg/m^2) and waist circumference (approximately −3.5 to −3.8 cm) compared to the no-exercise control ($p < 0.01$ for all comparisons), with no significant difference between HIIT and MICT for these outcomes ($p > 0.60$). This pattern equivalent body composition adaptations at substantially different time investment represents the core practical message of the present findings.

Table 3: Exercise Session Adherence and Adverse Events

Metric	HIIT Group	MICT Group
Mean Sessions Completed (of 36)	33.4 ± 2.1 (92.8%)	32.9 ± 2.6 (91.4%)
Dropout (n, %)	2 (6.7%)	2 (6.7%)
Minor Adverse Events	4 (muscle soreness)	3 (shin discomfort)
Serious Adverse Events	0	0

Source: Simulated training dataset (2026).

Adherence rates were comparably high in both groups (HIIT: 92.8%; MICT: 91.4%), with equivalent dropout rates (6.7% per group). No serious adverse events occurred in either arm. The four minor adverse events in the HIIT group (mild transient muscle soreness) resolved without intervention within 48–72 hours, confirming the tolerability of the HIIT protocol in the supervised sedentary young adult population.

Conclusion

This 12-week randomized controlled trial demonstrates that HIIT is superior to MICT for improving VO_2max in sedentary young adults, with a large effect size difference achieved in less than half the total exercise time. Body composition improvements reductions in BMI and waist circumference are equivalent between the two modalities. Both HIIT and MICT significantly outperform the no-exercise control on all outcome measures.

The time-efficiency advantage of HIIT (approximately 225 minutes less exercise per month for equivalent or superior fitness outcomes) has profound public health implications. Exercise promotion programmes targeting sedentary young adults should incorporate HIIT options to reduce the 'lack of time' adherence barrier, while maintaining MICT as an accessible entry-level alternative for those unable to tolerate high-intensity exercise demands.

Limitations include the supervised laboratory exercise setting (limiting real-world generalizability), the 12-week duration (insufficient to assess long-term maintenance), and the absence of dietary control. Future research should examine HIIT efficacy in unsupervised community settings, assess outcomes over 6–12 month follow-up periods, and investigate the impact of exercise enjoyment and psychological outcomes on long-term adherence in sedentary populations.

Ethical Statement

This article is an original academic training document. The dataset described is simulated for educational and formatting practice purposes. No real participant data, institutional data, or published datasets were reproduced. All author names, affiliations, and IRB references are placeholders. This work does not misrepresent any real research study, identity, or published findings.

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