RESEARCH ARTICLE

The effects of high-intensity interval training on physical fitness in sedentary adolescents: A comparative study with moderate-intensity continuous training

Wenzhi Guo[1, 2], Zhuoyan Lu[3], Zhaojin Zhong[4], Xiaocong Liu[2, *]

[1]Department of Sports, Suzhou Vocational Health College, Suzhou, Jiangsu, China. [2]School of Physical Education, Huizhou University, Huizhou, Guangdong, China. [3]College of Humanities and Law, Beijing University of Chemical Technology, Beijing, China. [4]Department of Sports, Wuxi Normal College, Wuxi, Jiangsu, China.

Received: December 26, 2025; **accepted:** May 26, 2026.

Sedentary behavior has become increasingly prevalent among Chinese adolescents owing to academic pressure and unhealthy lifestyle habits, contributing to impaired physical health and increased metabolic risk. This study compared the physiological effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) to determine whether a bio-monitored, time-efficient HIIT protocol could induce superior multidimensional fitness adaptations relative to traditional continuous aerobic training. A 12-week randomized controlled trial was conducted among 320 sedentary adolescents aged 14 – 18 years old. Unlike conventional observational approaches, this research utilized wearable heart rate telemetry to rigorously quantify training load, ensuring participants strictly maintained assigned physiological thresholds (HIIT: 85%–95% HRmax, MICT: 60%–70% HRmax). The results indicated that, while both modalities significantly reduced body weight and body mass index (BMI) with no between groups differences, HIIT induced superior adaptations in vital capacity, particularly among females. Furthermore, the HIIT group exhibited significantly greater improvements in speed, aerobic endurance, and lower-limb explosive power compared to the MICT group (P < 0.05). While MICT was effective for basic weight management, bio-monitored HIIT provided a more potent stimulus for enhancing cardiopulmonary function and neuromuscular performance, establishing it as a superior, time-efficient therapeutic strategy for reversing physical decline in sedentary youth.

Keywords: high-intensity interval training; moderate-intensity continuous training; physical fitness; sedentary; adolescents.

[*]**Corresponding author:** Xiaocong Liu, School of Physical Education, Huizhou University, Huizhou, Guangdong 516007, China. Email: lxc0426@hzu.edu.cn.

Introduction

In the 21st century, sedentary behavior (SB) has emerged as a critical public health challenge, particularly among adolescents. According to the Guidelines on Physical Activity and Sedentary Behavior published by the World Health Organization (WHO) in November 2020, sedentary behavior is officially defined as any waking behavior characterized by an energy expenditure of ≤ 1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture [1, 2]. The American Cancer Society further defines sedentary behavior as sitting for six or more hours per day [3]. In China, recent data utilizing triaxial accelerometer biotechnology reveals that 86.67% of adolescents on school days and 63.67% on non-school days spent more than 8 hours per day in sedentary activities with female students exhibiting longer sedentary time than males on both school and non-school days [4]. This prolonged inactivity is not merely a behavioral issue but a physiological stressor that downregulates insulin sensitivity, impairs lipid metabolism, and accelerates the loss of cardiorespiratory fitness [5].

Moderate-intensity continuous training (MICT) has traditionally been a primary exercise prescription for improving metabolic health. However, its real-world effectiveness is often limited by low adherence, primarily due to the substantial commitment required. Prolonged steady-state exercise can present behavioral barriers, particularly for individuals with low baseline fitness [6]. Consequently, the time required to achieve physiological adaptation *via* MICT often contributes to high attrition rates, including among school-aged populations [7]. High-intensity interval training (HIIT) has emerged as a time-efficient alternative. Evidence suggests that HIIT can yield physiological outcomes comparable or superior to MICT, despite a significantly lower time commitment [8]. Physiologically, HIIT offers specific metabolic benefits such as enhanced fat oxidation, preservation of lean mass, and elevated resting metabolic rate [9, 10]. High-intensity bouts stimulate myokine release and upregulate PGC-1α, a key regulator of mitochondrial biogenesis [11]. These mechanisms contribute to vascular adaptation, cellular energy metabolism, and cognitive-affective responses. Aerobic capacity is a primary indicator of cardiometabolic health. Meta-analyses indicate that HIIT generally elicits greater improvements in this metric than MICT [8]. Psychologically, HIIT presents a complex affective profile. Although ratings of perceived exertion (RPE) are higher and acute affective valence is lower during the intense intervals, post-exercise assessments often indicate higher overall enjoyment compared to MICT [12]. Furthermore, studies report that a large majority of adolescents prefer intermittent protocols over continuous exercise [12]. Despite the theoretical benefits of HIIT, the current research presents several gaps. Most comparative studies focus on adults, elite athletes, or clinically obese youth [13]. There is a paucity of large-scale randomized controlled trials (RCTs) specifically targeting sedentary adolescents who may not yet be obese but are "metabolically unfit". Moreover, many school-based interventions rely on self-reported exertion (RPE), which is inaccurate for adolescents. Few large-scale studies utilize wearable biometric monitoring such as heart rate telemetry to precisely quantify internal training load and ensure that "high intensity" zones are physiologically achieved. Furthermore, previous research often narrows its focus to BMI or VO2max alone. There is a need for comprehensive profiling that includes anaerobic power, speed, and pulmonary function, alongside an analysis of sex-specific responses to training stimuli.

This study aimed to bridge these gaps by conducting a comparative investigation into the physiological effects of a 12-week HIIT *versus* MICT intervention on the physical fitness of sedentary adolescents. By utilizing a cluster randomized controlled trial design, the comprehensive fitness indicators including body composition, pulmonary function (vital capacity), and performance metrics (speed, endurance, explosive power) were examined. Unlike traditional physical education interventions, this methodology integrated wearable biotechnology into the experimental protocol by using polar heart rate monitors to provide real-time biofeedback, ensuring that participants in the HIIT group maintained their heart rate in the critical 85 – 95% HRmax zone to trigger anaerobic metabolic adaptations. This research provided crucial evidence-based support for integrating time-efficient, technology-monitored HIIT into school physical education curricula to ultimately establish a highly effective therapeutic strategy for reversing physical decline in sedentary youth populations.

Materials and methods

Recruitment of research subjects

A total of 320 students aged from 16 to 18 years old, comprising 140 males and 180 females, were recruited by using cluster random sampling method from three high schools of Huizhou Middle School, Hua Luogeng Middle School, and Dongjiang Senior High School all located in Huizhou, Guangdong, China. Inclusion criteria included that participants aged between 16 and 18 years, lacked regular exercise habits (defined as engaging in physical activity fewer than three times per week with each session lasting no more than 20 minutes), and exhibited habitual sedentary behavior (defined as spending 20 hours or more per day sitting or lying down). Participants were assessed by using International Physical Activity Questionnaire (IPAQ) (https://sites.google.com/view/ipaq/download) [14]. Additionally, participants were free of any exercise contraindications as confirmed by the Physical Activity Readiness Questionnaire Plus (PAR-Q+) (https://eparmedx.com/print-versions-of-par-) [15], had maintained a stable body weight over the previous three months, and possessed a body mass index (BMI) ranging from 18.5 to 24 kg/m² [16]. Students were excluded from the study if they had been diagnosed with hypertension, heart disease, or arrhythmia, had a history of musculoskeletal disorders, joint problems, or muscle and ligament injuries, or reported experiencing discomfort or adverse reactions following exercise. Participants were considered for withdrawal or dropout if they voluntarily chose to leave the study or were unable to complete the intervention due to being late, interrupted, or absent three or more times. All participants were randomly assigned into experimental and control groups with 160 students in each group. The experimental group consisted of 68 male and 95 female, while the control group comprised 72 male and 85 female. All the procedures of this study were approved by the Institutional Review Board (IRB) of Huizhou Third People's Hospital (Huizhou, Guangdong, China).

Optimization of training protocol

Delphi method was employed to optimize the exercise training protocols. Semi-structured, in-depth interviews were conducted by 10 experts in the professional fields of physical education and training science, school physical education, sports rehabilitation, strength and conditioning, sports training, sport psychology, educational psychology, and sports health. The discussions focused on the experimental design of HIIT and MICT interventions including scientific rationale of the training protocols to evaluate the appropriateness of the HIIT and MICT models and provide optimization suggestions regarding training duration, intensity, rest intervals, and other critical parameters; safety and risk management to propose preventive mechanisms such as pre-exercise screening (PAR-Q+), exercise load control, and recovery strategies (dynamic and static stretching); and feasibility of implementation about the participant compliance, inclusion and exclusion criteria, feasibility of training implementation, and the validity of data collection, thereby refining the overall experimental design.

Intervention procedures

The intervention was designed to ensure equal training duration and frequency for both the experimental and control groups. One week prior to the intervention, both groups underwent baseline assessments of sedentary behavior, physical activity levels, and exercise contraindications using the IPAQ and PAR-Q+ questionnaires. Independent sample t-test was used to confirm no significant differences between groups at baseline. The experimental group received HIIT, while the control group received MICT. The intervention program lasted for 12 weeks with participants completing three 45-minute sessions per week, separated by a minimum 24-hour recovery interval. Each session was structured into three components including a 10-minute warm-up consisting of 5 minutes of jogging and 5 minutes of dynamic stretching, a 25-minute main training session either HIIT or MICT, and a 10-minute cool-down involving static stretching. During the 25-minute main training session, both HIIT and MICT groups performed an identical circuit of six bodyweight exercises to ensure that the biomechanical stimulus was consistent across groups. To facilitate gradual adaptation and prevent plateauing, the specific exercises were progressed every four weeks. In weeks 1 – 4, the circuit consisted of spot jogging, high knees (on the spot), wide-stance squat jumps, high knees with cross-body claps, butt kicks, and mountain climbers. During weeks 5 – 8, the exercises progressed to jumping jacks, burpees, bent-over jumping jacks, Russian twists, plank with alternating leg lifts, and forward lunges/jump lunges. In weeks 9 – 12, participants performed tuck jumps, plank jacks, alternating lunges/jumps, mountain climbers, high knees on the spot, and V-ups double crunches. These exercises were organized into a single circuit that was repeated four times per session. The primary procedural difference between the two groups laid in execution and intensity. HIIT group performed each exercise using a 2:1 work-to-rest ratio, consisting of 40 seconds of maximum effort followed by 20 seconds of rest with a 60-second recovery period granted between each of the four circuits. In contrast, the MICT group performed the exact same sequence of exercises but at a controlled, moderate pace continuously for the full 25 minutes with no intra-set or inter-set rest intervals. To rigorously quantify internal training load, participants' heart rates were continuously monitored throughout the sessions using Polar heart rate monitors. Maximum heart rate (HRmax) was calculated using the standardized adolescent formula below [17].

$$HRmax = 208 - 0.7 \times Age$$

The training intensity was progressed in stages. For HIIT group, the target intensity was set at 70 – 75% of HRmax for weeks 1 – 2, increased to 75 – 85% for weeks 3 – 5, reached 85 – 95% of HRmax for weeks 6 – 8, and maintained during weeks 9 – 12. For MICT group, the exercise intensity was maintained at 50 – 60% of HRmax for weeks 1 – 2, increased to 55 – 70% during weeks 3 – 5, and maintained at 60 – 70% from week 6 through week 12 [18]. Following the 12-week training program, post-intervention assessments were conducted within 24 – 72 hours using the same standardized protocols. Within group and between groups comparisons were then performed to evaluate the effects of the two training modalities on physical fitness outcomes in sedentary adolescents. The assessment measures included height, body weight, BMI, vital capacity, 1,000 m (male)/800 m (female) run, 50 m sprint, one-minute sit-ups (female)/pull-ups (male), sit-and-reach test, and standing long jump. Participants were required to wear standardized sports attire, avoid alcohol and caffeine intake, and refrain from engaging in vigorous physical activity other than the prescribed intervention [19].

Statistical analysis

All data were initially organized and standardized by using Microsoft Excel (Microsoft, Redmond, WA, USA) followed by statistical analysis conducted by SPSS version 26.0 (IBM, Armonk, NY, USA). Results were expressed as mean ± standard deviation (mean ± SD). Paired-sample t-test was applied to compare pre- and post-intervention data within each group, while independent-sample t-test was used to compare differences between groups. P value less than 0.05 indicated a statistically significant difference, while P value less than 0.01 indicated a highly significant difference.

Results

Pre- and post-intervention changes in body weight

Among male participants, body weight decreased significantly in both groups after the 12-week intervention. In the HIIT group, body weight declined from 68.21 ± 8.06 kg to 66.19 ± 5.01 kg, representing a mean reduction of 2.02 kg ($P < 0.01$). In the MICT group, body weight decreased from 67.52 ± 4.14 kg to 66.01 ± 4.02 kg, corresponding to a reduction of 1.51 kg ($P < 0.05$). BMI also decreased significantly in both male groups from 22.03 ± 3.42 to 21.91 ± 2.12 kg/m^2 in the HIIT group ($P < 0.001$) and from

Table 1. Comparison of body weight data in participants between two groups (mean ± SD).

Gender	Indicator	Group	Pre-intervention	Post-intervention	*P* (within group)
Male	Body weight (kg)	HIIT	68.21 ± 8.06	66.19 ± 5.01	0.005
		MICT	67.52 ± 4.14	66.01 ± 4.02	0.011
		P (between groups)	0.809	0.793	-
	BMI (kg/m²)	HIIT	22.03 ± 3.42	21.91 ± 2.12	0.000
		MICT	22.02 ± 3.04	21.13 ± 2.95	0.003
		P (between groups)	0.421	0.596	-
Female	Body weight (kg)	HIIT	60.87 ± 5.37	59.41 ± 3.06	0.000
		MICT	57.05 ± 6.05	55.68 ± 5.21	0.003
		P (between groups)	0.121	0.313	-
	BMI (kg/m²)	HIIT	22.36 ± 2.01	22.14 ± 1.14	0.000
		MICT	22.01 ± 1.81	21.98 ± 1.56	0.006
		P (between groups)	0.301	0.817	-

Table 2. Comparison of vital capacity (mL) data between two subject groups (mean ± SD).

Gender	Group	Pre-intervention	Post-intervention	*P* (within group)
Male	HIIT	4,001.24 ± 610.21	4,291.22 ± 623.61	0.004
	MICT	3,807.98 ± 521.77	3,907.21 ± 601.46	0.921
	P (between groups)	0.331	0.109	-
Female	HIIT	2,364.90 ± 323.98	2,564.68 ± 401.03	0.002
	MICT	2,566.61 ± 401.03	2,653.52 ± 453.32	0.612
	P (between groups)	0.443	0.021	-

22.02 ± 3.04 to 21.13 ± 2.95 kg/m² in the MICT group (P < 0.01). Among female participants, body weight likewise decreased significantly in both groups. In the HIIT group, body weight decreased from 60.87 ± 5.37 kg to 59.41 ± 3.06 kg, a mean reduction of 1.46 kg (P < 0.001). In the MICT group, body weight decreased from 57.05 ± 6.05 kg to 55.68 ± 5.21 kg, corresponding to a reduction of 1.37 kg (P < 0.01). BMI also showed significant reductions in both female groups, decreasing from 22.36 ± 2.01 to 22.14 ± 1.14 kg/m² in the HIIT group (P < 0.001) and from 22.01 ± 1.81 to 21.98 ± 1.56 kg/m² in the MICT group (P = 0.01). However, neither significant between groups differences were observed after the intervention for male body weight or BMI, nor for female body weight or BMI (Table 1). These findings indicated that both HIIT and MICT were effective in reducing body mass-related indices, but neither training modality demonstrated superiority over the other in these outcomes.

Pre- and post-intervention changes in pulmonary function

The results showed that the vital capacity improved significantly in the HIIT group for both sexes, whereas no significant within group changes were observed in the MICT group. Among male participants, vital capacity in the HIIT group increased from 4,001.24 ± 610.21 mL to 4,291.22 ± 623.61 mL, representing a mean increase of 289.98 mL (P < 0.01). In contrast, the MICT group changed from 3,807.98 ± 521.77 mL to 3,907.21 ± 601.46 mL with an increase of 99.23 mL but not statistically significant. The between groups difference after the intervention was not significant in males. Among female participants, vital capacity in the HIIT group increased from 2,364.90 ± 323.98 mL to 2,564.68 ± 401.03 mL, corresponding to a mean increase of 199.78 mL (P < 0.01). In the MICT group, vital capacity changed from 2,566.61 ± 401.03 mL to 2,653.52 ± 453.32 mL with an increase of 86.91 mL that was not statistically significant. The post-

Table 3. Comparison of physical fitness data in male participants between two groups (mean ± SD).

Indicator	Group	Pre-intervention	Post-intervention	*P* (within group)
50 m sprint (s)	HIIT	7.66 ± 0.82	7.31 ± 0.90	0.000
	MICT	7.38 ± 0.71	7.20 ± 0.52	0.000
	P (between groups)	0.708	0.060	-
1,000 m run (s)	HIIT	268.81 ± 11.30	252.17 ± 15.01	0.000
	MICT	255.03 ± 34.04	248.16 ± 33.19	0.030
	P (between groups)	0.211	0.031	-
Standing long jump (cm)	HIIT	210.51 ± 12.07	221.00 ± 13.39	0.001
	MICT	225.60 ± 15.03	225.07 ± 10.04	0.620
	P (between groups)	0.119	0.030	-
Pull-ups (reps)	HIIT	2.90 ± 3.20	3.08 ± 3.08	0.191
	MICT	3.41 ± 3.03	3.49 ± 2.71	0.920
	P (between groups)	0.811	0.858	-
Sit-and-reach (cm)	HIIT	9.19 ± 5.11	9.20 ± 5.98	0.262
	MICT	10.92 ± 7.01	11.03 ± 8.02	0.330
	P (between groups)	0.660	0.510	-

intervention between groups comparison showed statistically significant ($P < 0.05$) (Table 2).

Pre- and post-intervention changes in physical fitness

The changes in physical fitness indicators showed that, among male participants, significant improvements in 50 m sprint performance were observed in both groups. In the HIIT group, sprint time decreased from 7.66 ± 0.82 s to 7.31 ± 0.90 s ($P < 0.001$), while in the MICT group it decreased from 7.38 ± 0.71 s to 7.20 ± 0.52 s ($P < 0.001$). However, no significant difference between groups was found after the intervention. For endurance performance, the 1,000 m run time improved significantly in both groups, decreasing from 268.81 ± 11.30 s to 252.17 ± 15.01 s in the HIIT group ($P < 0.001$) and from 255.03 ± 34.04 s to 248.16 ± 33.19 s in the MICT group ($P < 0.05$) with a significant between group difference after the intervention ($P < 0.05$). In terms of lower-limb explosive power, standing long jump distance increased significantly in the HIIT group from 210.51 ± 12.07 cm to 221.00 ± 13.39 cm ($P < 0.01$), whereas no significant change was observed in the MICT group. The post-intervention difference between groups was significant ($P = 0.05$). No significant changes were observed in pull-up performance in either the HIIT group or the MICT group, and no difference between groups was found after the intervention. Similarly, sit-and-reach performance did not change significantly in either group with no significant difference between groups after the intervention (Table 3). Among female participants, 50 m sprint performance also improved significantly in both groups. Sprint time decreased from 9.66 ± 0.77 s to 9.44 ± 0.62 s in the HIIT group ($P < 0.001$) and from 9.73 ± 0.94 s to 9.35 ± 1.32 s in the MICT group ($P < 0.05$), although the between groups difference after the intervention was not significant. In the 800 m run, both groups showed significant improvements with times decreasing from 258.87 ± 13.28 s to 251.42 ± 16.51 s in the HIIT group ($P < 0.001$) and from 245.81 ± 28.21 s to 240.07 ± 29.29 s in the MICT group ($P < 0.05$). The difference between groups after the intervention was significant ($P < 0.05$). Standing long jump performance improved significantly in the HIIT group, increasing from 166.53 ± 9.27 cm to 174.00 ± 9.41 cm ($P < 0.01$), whereas no significant change was observed in the MICT group. The post-intervention difference between groups was significant ($P < 0.01$). In addition, one-minute sit-up performance improved significantly in the HIIT group from 34.91 ± 3.26

Table 4. Comparison of physical fitness data in female participants between two groups (mean ± SD).

Indicator	Group	Pre-intervention	Post-intervention	*P* (within group)
50 m sprint (s)	HIIT	9.66 ± 0.77	9.44 ± 0.62	0.000
	MICT	9.73 ± 0.94	9.35 ± 1.32	0.041
	P (between groups)	0.176	0.061	-
800 m run (s)	HIIT	258.87 ± 13.28	251.42 ± 16.51	0.000
	MICT	245.81 ± 28.21	240.07 ± 29.29	0.021
	P (between groups)	0.192	0.033	-
Standing long jump (cm)	HIIT	166.53 ± 9.27	174.00 ± 9.41	0.001
	MICT	165.00 ± 12.12	165.27 ± 12.24	0.791
	P (between groups)	0.201	0.001	-
Sit-ups (reps)	HIIT	34.91 ± 3.26	42.07 ± 5.19	0.000
	MICT	33.54 ± 4.33	34.34 ± 4.67	0.153
	P (between groups)	0.701	0.001	-
Sit-and-reach (cm)	HIIT	15.18 ± 5.12	15.08 ± 5.19	0.412
	MICT	16.09 ± 2.09	16.03 ± 2.56	0.233
	P (between groups)	0.663	0.708	-

to 42.07 ± 5.19 repetitions ($P < 0.001$), while no significant improvement was observed in the MICT group. The difference between groups after the intervention was significant ($P < 0.01$). No significant changes were found in sit-and-reach performance in either the HIIT group or the MICT group, and no significant difference between groups was observed after the intervention (Table 4). Overall, both HIIT and MICT improved specific physical fitness indicators in sedentary adolescents. Specifically, HIIT yielded broader and more significant improvements in endurance, lower body explosive power, and abdominal muscular endurance in females, whereas neither intervention significantly improved flexibility.

Discussion

Impact of HIIT and MICT on body weight in sedentary adolescents

Both HIIT and MICT produced significant reductions in body weight and BMI after the 12-week intervention. However, because no significant difference between groups were observed in either sex, the present findings suggested that the two time-matched exercise programs had broadly comparable effects on body mass-related outcomes. Accordingly, the practical and clinical advantage of HIIT within this specific context might lie more profoundly in its exceptional time efficiency rather than in a demonstrably superior capacity for weight reduction. A plausible explanation was that both training modalities increased overall energy expenditure and improved metabolic regulation in previously sedentary adolescents. HIIT might additionally induce greater excess post-exercise oxygen consumption and stronger mitochondrial and lipolytic adaptations than continuous exercise [20-22]. Nevertheless, in the present study, these potential physiological advantages did not translate into statistically greater reductions in body weight or BMI than those observed with MICT. Therefore, HIIT should be interpreted as an effective alternative to MICT for weight management in sedentary adolescents rather than as a definitively superior approach.

Impact of HIIT and MICT on pulmonary function in sedentary adolescents

HIIT has been shown to significantly enhance pulmonary function in sedentary adolescents with effects superior to those of traditional MICT [23]. The results of this study was consistent with the previous findings, suggesting that HIIT was a feasible and effective method for improving adolescents' respiratory health. The greater improvement in pulmonary function observed in the HIIT group might be attributed to the high-intensity and intermittent nature of the training. Previous studies have demonstrated that the alternating intensity patterns of HIIT can substantially improve gas exchange efficiency in the lungs and promote more effective physiological regulation [24]. The intermittent bouts of high-intensity activity induce rapid breathing and accelerated heart rate, forcing the body to reach near-maximal exertion within a short time frame [25]. From a physiological standpoint, the "all-out" intervals act as a high-resistance training stimulus for the diaphragm and intercostal muscles, improving respiratory mechanics and lung compliance in a way that steady-state MICT does not.

Impact of HIIT and MICT on physical fitness in sedentary adolescents

The analysis revealed that both HIIT and MICT significantly improved the overall physical fitness of sedentary adolescents, although the effects varied across different fitness domains. In terms of speed and endurance, both training modalities significantly enhanced performance in the 800 m, 1,000 m, and 50 m run tests. HIIT demonstrated a greater magnitude of improvement compared to MICT. For muscular strength, sit-up and standing long jump performance showed significant improvements in the HIIT group but not in the MICT group, indicating that moderate-intensity training provided insufficient stimulation for strength development. The superior improvements in explosive power and core strength observed in the HIIT group could be attributed to the activation of type IIa muscle fibers, which played a critical role in speed- and strength-oriented activities [26]. Furthermore, high-intensity efforts predominantly consumed muscle glycogen and enhanced adaptations in anaerobic metabolism [27]. Conversely, pull-up performance neither improved significantly in either group nor made differences between groups, suggesting that the intervention failed to adequately stimulate upper-body musculature as most prescribed exercises focusing on lower-limb and core strength. With respect to flexibility, neither training modality yielded substantial improvements, which might be explained by shortened hamstrings and restricted hip mobility due to prolonged sedentary behavior [28], as well as the frequent neglect of stretching exercises by the subjects during intervention programs. Moreover, performance in the sit-and-reach test required combined flexibility of the lumbar spine and shoulder joints, making improvements more challenging without targeted stretching interventions.

Both HIIT and MICT produced significant reductions in body weight and BMI in sedentary adolescents with no significant difference between groups in body composition outcomes. In contrast, HIIT elicited significant improvements in vital capacity, whereas MICT did not show significant within group changes, and this advantage appeared more evident among female participants. With respect to physical fitness, both training modalities improved speed and endurance, but HIIT produced broader benefits in aerobic endurance and lower-limb explosive power, as well as superior improvement in female abdominal muscular endurance. Neither intervention substantially improved flexibility, suggesting that targeted mobility or stretching exercises might be required to optimize this component of fitness. These findings supported heart-rate-monitored HIIT as a time-efficient and effective alternative to MICT for improving multidimensional physical fitness in sedentary adolescents. Future research should further leverage biotechnology by incorporating individualized load monitoring and longer-term follow-up to evaluate the sustainability of these adaptations.

Acknowledgements

This research was supported by the 2025 Huizhou Philosophy and Social Science Planning Project (Grant No. HZSK2025GJ179) and Higher Vocational Education Teaching Reform Research and Practice Project of Guangdong University Teaching Management Association in 2024 (Grant No. GDGX202401084).

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