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Original Scientific Article

Engaging in High-Intensity Interval Training is More Effective than Moderate-Intensity Interval Training in Improving Aerobic Capacity and Body Composition in Students

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Objectives. This study aimed to prove the difference in the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on increasing aerobic capacity and improving body composition.

Materials and methods. This study examined the effects of two different training methods – moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) on aerobic capacity and body composition among 30 university students aged 19-22, using a pretest-posttest control group design. Participants were randomly assigned to either the MICT, HIIT, or Control (no training) groups and trained three times a week for four weeks. Aerobic capacity was measured with the 12-Minute Cooper Test, and body composition was assessed using the TANITA BC-545N. Data analysis included descriptive statistics, normality tests and ANOVA tests to evaluate group differences.

Results. The results indicate that HIIT yields greater enhancements in aerobic capacity and body composition (e.g., reduced body fat and increased fat-free mass) compared to MICT, while the CTRL group appears to demonstrate minimal changes. Additionally, no significant differences in BMI were observed between the three groups ($p \geq 0.05$).

Conclusions. These findings suggest that HIIT may serve as an effective training approach for individuals seeking optimal fitness gains and improved body composition with shorter exercise durations.

Keyword: aerobic capacity, body composition, healthy lifestyle, exercise, physical fitness.

Introduction

Low levels of physical activity among college students are often caused by a variety of factors, such as academic demands, lifestyle, and lack of support or facilities. Lack of physical activity can result in decreased cardiovascular health, which is at risk of increasing heart disease and hypertension in the future (Wilhite et al., 2023). Low physical activity makes the cardiovascular system and heart not function properly, potentially causing long-term health problems. In addition, low physical activity reduces calorie burning; If accompanied by an unhealthy diet, this can contribute to weight gain or even obesity (Ashadi et al., 2024). Obesity at a young age can have adverse health effects, including an increased risk of type 2 diabetes, hypertension, and other chronic diseases (Binsaeed et al., 2023).

Barriers to training time management are often the main reason students don't exercise regularly. Previous research indicates that moderate intensity continuous training (MICT) is effective in burning body fat, because this method keeps the body in the fat burning zone for a long time (Muhammad et al., 2024). However, moderate intensity continuous training also has some drawbacks that

can affect its effectiveness in burning fat and providing long-term fitness benefits (Paria et al., 2024). Moderate intensity continuous training takes longer to burn a significant amount of calories or fat compared to high-intensity workouts such as high intensity interval training (Yin et al., 2023). This becomes a challenge for individuals with busy schedules, as these exercises take longer to achieve similar results. Moderate intensity continuous training also produces a low excess post-exercise oxygen consumption (EPOC), meaning that after the workout session is over, the body does not burn a large amount of additional calories, so the fat burning effect is reduced faster compared to high-intensity exercise (Isanejad et al., 2023).

Moderate-intensity continuous training involves activities that are performed at a consistent pace or intensity over a long period of time, such as running or cycling at a moderate pace (Namboonlue et al., 2024). This routine tends to feel monotonous and can reduce long-term motivation, so many people find it difficult to stay consistent in practice (Gerosa-Neto et al., 2020). In addition, the body can quickly adapt to the constant intensity of moderate exercise, so the benefits of moderate intensity continuous training in terms of calorie burning and fitness improvement can decrease over time (Choudhary & Dubey, 2024). Once the body gets used to it, those benefits may diminish unless the duration or intensity of the exercise is increased, which requires additional time and effort (Rolid et al., 2020). Moderate intensity continuous training does not significantly stimulate muscle growth because it puts more emphasis on duration than strength or energy bursts. This type of exercise is less optimal for those who want to improve body composition through increased muscle mass, since it does not provide a sufficiently intense load or stimulation to the muscles (Lu et al., 2022).

High intensity interval training (HIIT) is more able to stimulate metabolic hormone responses such as epinephrine, which is more effective at burning fat compared to moderate intensity continuous training (Khalafi et al., 2020). In moderate intensity continuous training, the release of these hormones is less, so the impact on fat metabolism is not as strong as high-intensity exercise (Aparecido et al., 2022). Moderate intensity continuous training is generally successful in improving cardiovascular fitness, but it is less effective at increasing strength, explosiveness, or flexibility (Yu et al., 2022). For individuals looking to achieve a variety of fitness goals, moderate intensity continuous training is less flexible compared to exercises that offer variety in intensity and type (Ruíz-Uribe et al., 2024).

Individuals with limited time to train in order to improve aerobic capacity and improve body composition significantly, moderate intensity continuous training may not be the best option (Youssef et al., 2022). Therefore, The novelty of this study to proves that high intensity interval training offers some important new elements compared to moderate intensity continuous training, especially in terms of its effectiveness to increase aerobic capacity and improve body composition in college students who have a less active lifestyle. These new elements include intensity, movement variation, EPOC, after-burn effects, as well as the long-term impact of HIIT that cannot be achieved with the moderate intensity continuous training intervention (Khodadadi et al., 2023). High intensity interval training can lead to more significant improvements in aerobic capacity and body composition compared to moderate intensity continuous training (Casaña et al., 2022). High intensity interval training has been shown to be more effective in increasing VO_2 max, which is the body's ability to utilize oxygen optimally, as it encourages the cardiovascular system to work harder and adapt faster (Hu et al., 2021). In addition, the post-workout calorie burn (EPOC) effect on HIIT is also higher, so the body continues to burn more fat even after the workout session is over (Martínez-Rodríguez et al., 2021). Therefore, HIIT is an efficient option to improve cardiovascular health, burn body fat, and improve overall body composition (Gaweł et al., 2024).

This study aims to prove that high intensity interval training (HIIT) is superior to moderate intensity continuous training (MICT) in increasing aerobic capacity and improving body composition. This research contributes to various aspects of fitness and health that are very important for the global community, especially in efforts to promote healthy lifestyles, time efficiency, and long-term health management. The findings proving that HIIT is more effective than MICT in improving aerobic capacity, body composition, and overall health are invaluable to the international community. In addition, the study not only provides solutions to public health problems, but also presents valuable information for individuals looking for more efficient ways to exercise.

Material and Methods

Study design

This study involved a total of 30 young students who were participants. The inclusion criteria were individuals aged 19-22 years, body mass index (BMI) 15-25 kg/m^2, normal systolic and diastolic blood pressure 120-110/90-80 mmHg, resting heart rate (RHR) 70-90 bpm, oxygen saturation 97-100 %, and body temperature 36.5-37.2 °C. Subjects were verified to have no history of smoking, non-alcoholic consumption, non-hypertension, and non-diabetes. In addition, the participants did not have any disease with personalised therapy through specific medical interventions. The study involved two independent variables: moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT), as well as two dependent variables: aerobic capacity and body composition. Following informed consent, subjects underwent health screenings and pretests for aerobic capacity and body composition and were then randomly assigned into three groups: the MICT group, the HIIT group, and a control group with no training. The training program was implemented over a 4-week period with a frequency of three sessions per week (Table 1).

Data Collection

The research process was carried out with the following steps: first, the research subject fills out an approval form. After agreeing to participate, all participants underwent a health check, including pulse and blood pressure measurements, as well as a pretest for aerobic capacity and body composition. The subjects were then randomly divided into three groups: A, B, and C. Group A underwent moderate-intensity continuous training (MICT), group B did high-intensity interval training (HIIT), while group C did not exercise. The exercise program lasts for 4 weeks with

Table 1. HIIT and MICT training program

Groups	MICT's Group (Group A, n = 10)	HIIT's Group (Group B, n = 10)	Control's Group (Group C, n = 10)
Intensity week 1	1. 70 % MAS 40 Min	15 s @100 % MAS : 15 s 70 % MAS X 10 Reps (3 Min Rest BS) X 4 Set	No Training
Intensity week 2	2. 70 % MAS 50 Min	15 s @107 % MAS : 15 s 70 % MAS X 10 Reps (3 Min Rest BS) X 4 Set	No Training
Intensity week 3	3. 70 % MAS 50 Min	16 s @114 % MAS : 15 s 70 % MAS X 10 Reps (3 Min Rest BS) X 4 Set	No Training
Intensity week 4	4. 70 % MAS 60 Min	17 s @120 % MAS : 15 s 70 % MAS X 10 Reps (3 Min Rest BS) X 4 Set	No Training

a frequency of 3 times a week. After the 4-week intervention period, it was followed by a posttest to re-measure the subject's aerobic capacity and body composition. Aerobic capacity was measured with the 12-Minute Cooper Test, and body composition was assessed using the TANITA BC-545N.

Statistical Analysis

Descriptive statistical analysis was applied to assess the mean and standard deviation. Shapiro–Wilk and Levene's test were applied to assess the normality and homogeneity of the data. Data that is normally distributed and has homogeneous variance is assessed using the one-way ANOVA test and followed by the LSD post-hoc test to assess differences between groups. Meanwhile, paired sample t-test was applied to assess baseline (pre) and 4 week (post) data in each group for all research variables. All statistical analyzes were implemented with SPSS Statistics for Windows version 21.0. Data was declared to have a significant difference if $p < 0.05$.

Results

The results of the analysis of assessment of aerobic capacity and body composition at baseline (pre) and 4 weeks (post) in each group are presented in Figure 1-4.

The results of the aerobic capacity analysis in Figure 1 show a significant increase after intervention for 4 weeks (post) compared to baseline (pre) at MICT ($p = 0.006$; ES: 0.859; 95 % CI: -7.01, -1.62), and at HIIT ($p = 0.683$; ES: 0.112; 95 % CI: -2.11, 3.07), while there was no significant difference at CTRL observed ($p = 0.000$; ES: 1.086; 95 % CI: -8.89, -6.48).

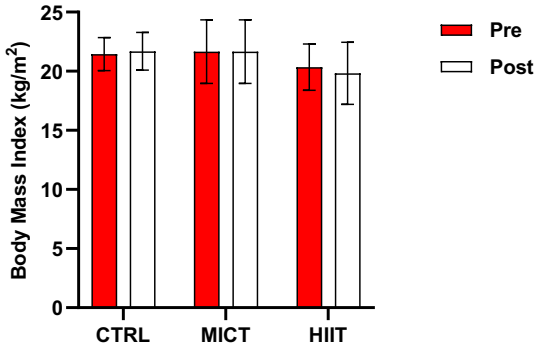

Fig. 2. Assessment of body mass index baseline (pre) and 4 week (post) in each group. *Significant at baseline (pre) $p \leq 0.05$. Data are presented as mean ± SD. The p-value was obtained from the paired sample t-test assessment

The results of the body mass index analysis in Figure 2 do not show any significant changes observed between baseline (pre) and 4 weeks (post) intervention at CTRL ($p = 0.156$; ES: 0.163; 95 % CI: -0.60, 0.11), at MICT ($p = 0.990$; ES: 0.001; 95 % CI: -0.34, 0.34), and at HIIT ($p = 0.167$; ES: 0.219; 95 % CI: -0.26, 1.27).

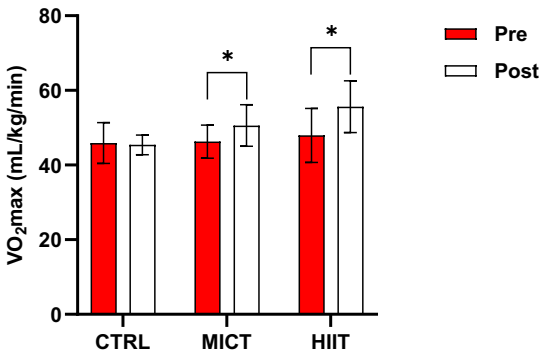

Fig. 1. Assessment of aerobic capacity baseline (pre) and 4 week (post) in each group. *Significant at baseline (pre) $p \leq 0.05$. Data are presented as mean ± SD. The p-value was obtained from the paired sample t-test assessment

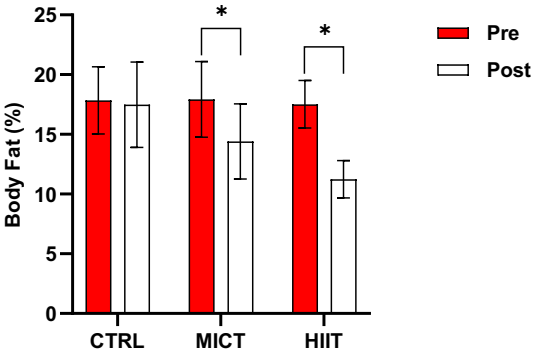

Fig. 3. Assessment of body fat baseline (pre) and 4 week (post) in each group. *Significant at baseline (pre) $p \leq 0.05$. Data are presented as mean ± SD. The p-value was obtained from the paired sample t-test assessment

Table 2. Assessment of aerobic capacity and body composition in all participants

Parameters	CTRL, n = 10	MICT, n = 10	HIIT, n = 10	p-value
Pre-VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	45.89 ± 5.48	46.27 ± 4.44	47.94 ± 7.22	0.709
Post-VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	45.41 ± 2.62	50.59 ± 5.55*	55.63 ± 6.92*†	0.001
Δ-VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	-0.49 ± 3.62	4.32 ± 3.77*	7.69 ± 1.69*†	0.000
Pre-BMI (kg/m^2)	21.44 ± 1.39	21.65 ± 2.69	20.34 ± 1.96	0.333
Post-BMI (kg/m^2)	21.69 ± 1.59	21.65 ± 2.69	19.83 ± 2.62	0.151
Δ-BMI (kg/m2)	0.25 ± 0.50	0.00 ± 0.47	-0.51 ± 1.07	0.082
Pre-BF (kg)	17.85 ± 2.81	17.93 ± 3.17	17.52 ± 1.99	0.938
Post-BF (kg)	17.48 ± 3.57	14.40 ± 3.15*	11.24 ± 1.57*†	0.000
Δ-BF (kg)	-0.37 ± 1.61	-3.53 ± 0.96*	-6.28 ± 1.91*†	0.000
Pre-FFM (kg)	50.18 ± 3.41	52.25 ± 3.49	48.66 ± 4.57	0.132
Post-FFM (kg)	50.37 ± 3.55	54.87 ± 3.89*	54.04 ± 3.78*	0.028
Δ-FFM (kg)	0.19 ± 0.61	2.62 ± 1.38*	5.39 ± 1.67*†	0.000

* Significant at CTRL $p \leq 0.05$. †Significant at MICT $p \leq 0.05$. Data are presented as mean ± SD. The p-value was obtained from the one-way ANOVA followed by LSD post-hoc test

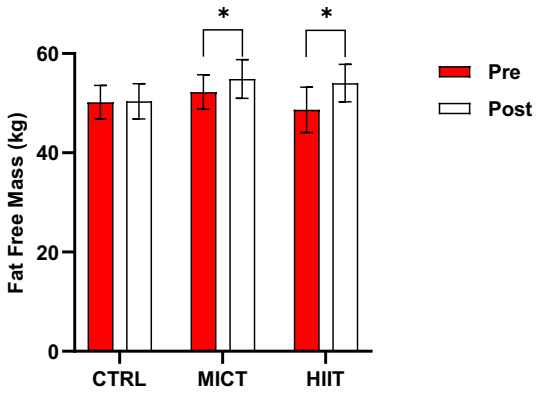

Fig. 4. Assessment of body fat baseline (pre) and 4 week (post) in each group. *Significant at baseline (pre) $p \leq 0.05$. Data are presented as mean ± SD. The p-value was obtained from the paired sample t-test assessment

The results of body fat analysis in Figure 3 show a significant reduction after 4 weeks of intervention (post) compared to baseline (pre) at MICT ($p = 0.000$; ES: 1.118; 95 % CI: 2.84, 4.22), and at HIIT ($p = 0.000$; ES: 3.501; 95 % CI: 4.92, 7.64), while at CTRL no significant differences were observed ($p = 0.487$; ES: 0.115; 95 % CI: -0.79, 1.53).

The results of the free fat mass analysis in Figure 4 show a significant increase after 4 weeks of intervention (post) compared to baseline (pre) at MICT ($p = 0.000$; ES: 0.709; 95 % CI: -3.61, -1.64), and at HIIT ($p = 0.000$; ES: 1.284; 95 % CI: -6.58, -4.19), whereas at CTRL no significant difference was observed ($p = 0.487$; ES: 0.115; 95 % CI: -0.79, 1.53). Assessment of aerobic capacity and body composition in all participants was presented in Table 2.

Discussion

High-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) are two popular workout methods aimed at enhancing aerobic capacity and improving body composition, particularly in reducing body fat and increasing muscle mass. Although both interventions are effective, research findings indicate that HIIT is significantly more efficient than MICT in achieving these outcomes. The body burns more calories at higher intensities during HIIT interventions compared to moderate continuous exercise. This is particularly crucial for students with limited time, as they require effective and efficient workouts to quickly enhance aerobic capacity and burn fat (Domaradzki et al., 2023).

High intensity interval training exercise interventions resulted in faster improvements in heart and lung efficiency compared to moderate intensity continuous training (Marcotte-Chénard et al., 2021). High-intensity training increases heart volume per beat (stroke volume) and lung capacity to deliver oxygen to the muscles, which accelerates the body's cardiovascular adaptation and contributes to a significant increase in VO_2max (Russomando et al., 2020). The combination of periods of high intensity with periods of rest allows the body to function at a higher capacity in a short period of time, resulting in an increase in better aerobic efficiency (Guo et al., 2023). Meanwhile, while MICT is effective for maintaining fitness, its increase in aerobic capacity tends to be slower and less significant due to its stable and moderate intensity during exercise (Scoubeau et al., 2022).

One of the factors that makes high intensity interval training more efficient in increasing aerobic capacity is due to the excess post-exercise oxygen consumption (EPOC) effect. After a HIIT session, the body still burns more oxygen and calories for the recovery process (Domaradzki et al., 2022). This excess post-exercise oxygen consumption (EPOC) contributes to an increase in the body's aerobic efficiency, which does not occur in moderate intensity continuous training (Moro et al., 2020). Moderate intensity continuous training generally does not produce such an effect, so the body's recovery does not contribute to an increase in aerobic capacity in the long term (Murawska-Cialowicz et al., 2020).

The composition of the body consists of fat mass and fat-free mass, which includes muscle. High-Intensity Interval Training (HIIT) improves the efficiency of the body's energy use, both during exercise and afterwards (Koźlenia et al.,

2024). High-intensity interval training promotes significant calorie burning, including calories from fat, both during training sessions and during recovery through the EPOC effect (Hooshmand Moghadam et al., 2021). This process is more effective in reducing body fat, including visceral fat that surrounds internal organs and is associated with the risk of metabolic diseases (Fang et al., 2021).

Increasing muscle mass through HIIT interventions has been shown to be more effective compared to MICT exercises (Unterberger et al., 2022). HIIT involves exercises that use large muscle groups and prioritize muscle strength, such as squats, jumping, and sprints. This movement not only increases aerobic capacity but also stimulates muscle growth. In contrast, MICT focuses more on cardiovascular endurance, while HIIT contributes to increased strength and muscle mass, which can further speed up the body's metabolism (Alarcón-Gómez, Chulvi-Medrano, et al., 2021). With higher muscle mass, the body can burn more calories even when at rest (Alarcón-Gómez, Calatayud, et al., 2021).

The advantages of HIIT in reducing subcutaneous fat and belly fat have proven to be significantly more effective. Research shows that HIIT is more successful in reducing subcutaneous body fat, which is the fat located under the skin, as well as belly fat, which is more difficult to remove (Atakan et al., 2021). On the other hand, although MICT also helps in fat reduction, this method does not specifically target belly fat and does not provide results as fast as HIIT. One of the main advantages of HIIT workouts is their shorter duration, which is about 20 to 30 minutes, but still gives comparable or even better results compared to longer workouts such as MICT (30-60 minutes) (Duarte Martins et al., 2024). HIIT offers higher effectiveness in a more efficient time, making it an attractive option for those with busy schedules, especially housewives or workers with limited time to exercise (Jiménez-Maldonado et al., 2020). HIIT programs can improve adherence to exercise routines because of their shorter duration and more dynamic nature, making many individuals feel more motivated to practice HIIT consistently (Zhang et al., 2022). In contrast to MICT which tends to be monotonous and requires more endurance, HIIT is more appealing to many people, thus helping to improve long-term compliance (Wang et al., 2020).

Previous research indicates that HIIT, performed only 2-3 times a week, can increase aerobic capacity by 25-30 % in a short period of time (about 2-3 weeks), while MICT requires more time and frequency of exercise to achieve equivalent results (Songsorn et al., 2022). A meta-analysis of various studies showed that HIIT was more effective in reducing body fat compared to MICT, where the decrease in visceral fat and the increase in muscle mass were more significant (Rolid et al., 2020). Individuals who underwent a HIIT program experienced an increase in VO2 max and a greater decrease in body fat percentage compared to those who followed a MICT program of the same duration (Flensted-Jensen et al., 2021).

HIIT is much more effective than MICT in increasing aerobic capacity and improving body composition. One of the main advantages of HIIT is its ability to accelerate cardiovascular improvement and boost metabolism in less time (Lu et al., 2022). HIIT is also more efficient at reducing body fat, including belly fat, as well as stimulating the growth of muscle mass. With shorter durations and higher workout variation, HIIT is also more acceptable and appealing to those who have limited time or who prefer a more dynamic workout (Legaard et al., 2022). Therefore, HIIT is a more efficient and effective option for achieving fitness goals, especially when it comes to increasing aerobic capacity and improving body composition (Ballesta-García et al., 2020).

The research indicates that HIIT is more effective than MICT for enhancing aerobic capacity and body composition, but there are some limitations to consider. These limitations include the impact of overall diet and lifestyle, which can influence exercise outcomes. Without careful monitoring of calorie intake, sleep quality, and stress levels, the results of HIIT or MICT may not solely reflect the effects of exercise. The study focused exclusively on sports students who were already physically active outside of the provided interventions. Conversely, data suggests that non-sports students might be more susceptible to obesity due to various lifestyle factors, stress, and time constraints. To obtain more reliable and generalizable results, additional research with larger sample sizes and longer intervention periods is required.

Conclusions

The conclusions of this study showed that the group that followed the high-intensity interval training intervention proved to be more effective compared to continuous moderate-intensity exercise in improving aerobic capacity and improving body composition. These findings are relevant for a wide range of health and fitness programs, especially for less active individuals. Practically, the results of this research can be used to design a more efficient, accessible, and flexible fitness program for people who have limited time. With appropriate adjustments, these results have the potential to have a positive impact on the physical and mental health of the community.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Виконання високоінтенсивних інтервальних тренувань є ефективнішим за проведення інтервальних тренувань помірної інтенсивності з точки зору покращення аеробної здатності та композиції тіла у студентів

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 2 табл., 4 рис., 47 джерела.

Мета дослідження. Мета цього дослідження полягала в доведенні різниці щодо впливу високоінтенсивного інтервального тренування (ВІІТ) та безперервного виконання тренування помірної інтенсивності (БТПІ) на підвищення показників аеробної здатності та поліпшення компонентного складу тіла.

Матеріали та методи. У цьому дослідженні вивчався вплив двох різних методик тренувань — безперервного тренування помірної інтенсивності (БТПІ) та високоінтенсивного інтервального тренування (ВІІТ) на показники аеробної здатності та композиції тіла у 30 студентів університету віком 19-22 років, використовуючи модель контрольної групи з претест-посттестовим дизайном. Учасників було рандомізовано до груп, що займалися БТПІ, ВІІТ або контрольної групи (без виконання тренувань). Тренування проводились тричі на тиждень протягом чотирьох тижнів. Вимірювання аеробної здатності проводилось за допомогою 12-хвилинного тесту Купера, а визначення компонентного складу тіла

здійснювалось із використанням пристрою TANITA BC-545N. Аналіз даних включав описові методи статистики, тести на нормальність розподілу та тести дисперсійного аналізу (ANOVA) з метою оцінки відмінностей між групами.

Результати. Результати вказують на те, що застосування ВІІТ призводить до значнішого покращення показників аеробної здатності та компонентного складу тіла (наприклад, зниження вмісту жиру в організмі та підвищення безжирової маси тіла) порівняно з БТПІ, тоді як контрольна група демонструє мінімальні зміни. Крім того, між трьома групами не спостерігалося суттєвих відмінностей в показниках ІМТ ($p \geq 0,05$).

Висновки. Отримані дані свідчать про доцільність застосування ВІІТ як ефективного тренувального підходу для осіб, які прагнуть досягти оптимального рівня фізичної підготовленості та покращити композицію тіла за допомогою коротших за тривалістю тренувань.

Ключові слова: аеробна здатність, композиція тіла, здоровий спосіб життя, фізичні вправи, фізична підготовленість.

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