International Journal of Public Health Excellence (IJPHE)
Vol. 5, Issue 1, June-December 2025, pp. 113~1119
Journal Homepage: https://ejournal.ipinternasional.com/index.php/ijphe
ISSN: 2809-9826, DOI: 10.55299/ijphe.v5i1.1515

Differences In Effect Of High-Intensity Interval Training And Moderate-Intensity Continuous Training On Cardiorespiratory Fitness and Waist-To-Hip Ratio In Overweight Adolescents In Denpasar

Salsabila Fernanda Djuliana[1], Luh Putu Ratna Sundari[2], Nur Basuki[3], I Putu Adiartha Griadhi[4], I Dewa Ayu Inten Dwi Primayanti[5], Indira Vidiari Juhanna[6]

[1] Master Program of Sport Physiology, Faculty of Medicine, Udayana University, 80234, Denpasar, Indonesia
[2,4,5,6] Department of Physiology, Faculty of Medicine, Udayana University, 80234, Denpasar, Indonesia
[3] Department of Physiotherapy, Poltekes Kemenkes Surakarta, 57127, Surakarta, Indonesia

Article Info

Article history:

Received august 21, 2025
Revised September 14, 2025
Accepted October 21, 2025

Corresponding Author:

Salsabila Fernanda Djuliana
Master Program of Sport Physiology, Faculty of Medicine, Universitas Udayana, Denpasar, Indonesia
Email:
salsa.fdjuliana@gmail.com

ABSTRACT (10 PT)

Overweight has become a serious public health issue, as proven by the increasing morbidity and mortality rates in this population. Therefore, physical exercise interventions such as high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) are needed as training programs that can improve cardiorespiratory fitness (CRF) and reduce cardiometabolic risk. The aim of this study is to determine the differences in the effects of HIIT and MICT on CRF and the waist-to-hip ratio (WHR). This study used the randomized control group pretest-posttest design research method. The research sample included of 20 adolescents divided into two groups. Group 1 received the HIIT intervention, and Group 2 received the MICT intervention. CRF was assessed using the 20-meter shuttle run test (20m-SRT) also WHR. The mean test on CRF show that in group 1 ($p<0.05$) and group 2 ($p<0.05$) there are significant differences pre and post-test training. The Mann-Whitney U-test results show significant difference ($p<0.05$). Meanwhile, the WHR mean test results show that in group 1 ($p<0.05$) and group 2 ($p<0.05$) also has significant differences pre and post-test training. The Independent sample t-test results show no significant difference ($p>0.05$). This study concluded that HIIT is more effective than MICT in improving cardiorespiratory fitness. Thus, HIIT is as effective as MICT in reducing the waist-to-hip ratio of overweight adolescents.

Keywords:

high-intensity interval training, moderate-intensity continuous training, cardiorespiratory fitness, waist-to-hip ratio

1. INTRODUCTION

The incidence of obesity in Indonesia has been increasing each year, in line with the rising percentage of non-communicable diseases. Being overweight is a crucial factor in preventing obesity and reducing the risk of health disorders. Sedentary lifestyle has become a common behavior in society today as a negative impact of technological advancement1. Learning activities are now dominated by the use of technology, resulting in longer sitting durations for students outside of school hours. Changes in the social environment also impact behavior, leading to a lack of activity, which has negative effects by not reaching daily physical activity needs and increasing sedentary behaviour2. Overweight and obesity have become serious public health issues, owing to their rapidly increasing prevalence worldwide. Rising morbidity and mortality rates indicate a declining health status in this population. This is supported by the fact that obese individuals are more susceptible to developing diabetes mellitus, hypertension, and cardiovascular diseases3.

The prevalence of sedentary lifestyles has been increasing every year, including among adolescents. In 2016, global data covering 146 countries showed that 80% of individuals aged 11-17 did not meet the minimum daily physical

activity requirements4. The prevalence of sedentary lifestyle in Indonesia in 2013 was 26.1%, which increased to 33.5% in 20185. In line with the lack of physical activity associated with a sedentary lifestyle, the prevalence of overweight has increased. Based on 2018 Riskesdas data, Indonesia experienced a change in prevalence in the age range of 16 – 18 years, from 7.3% in 2013 to 13.5%, consisting of 9.4% overweight and 4% obesity6. Bali Province showed a relatively high percentage of overweight and obesity in 2018 health report data, with 21.8% in the age range of 12 – 15 years and 17.5% in the age range of 16 – 18 years. This high percentage will certainly affect the health condition of the productive-age population in the future, if not addressed immediately7.

Failure to reach minimum daily physical activity requirements affects fitness levels. Maximal oxygen consumption ability (VO2max) is related to body composition. Fatty acids have influence on the process of homeostasis disruption of intramuscular homeostasis can lead to inadequate energy production, resulting in muscle fatigue. An increase in oxygen consumption plays an important role in maintaining cardiorespiratory function, thereby maintaininf optimal body fitness 8. The American College of Sports Medicine (ACSM) recommends moderate-intensity continuous training (MICT) as an option for changing body composition. MICT is a form of exercise with moderate intensity and long duration, characterized by an exercise duration of 30 – 50 minutes and a heart rate ≤80% of the maximum heart rate (HRmax). From a physiological perspective, MICT affects the reduction of fat mass as a result of increased utilization and production of glycogen and fatty acids during activity. MICT is a choice for improving cardiorespiratory fitness; however, it is performed over a relatively long duration9.

In recent years, high-intensity interval training (HIIT) has become a popular exercise program. In addition to its effect on cardiorespiratory function, time efficiency is an advantage of high-intensity exercise programs. A shorter duration, accompanied by its benefits, makes HIIT more attractive 10. The HIIT uses the percentage of ≥90% HRmax interspersed with active recovery between intervals. In addition to being beneficial for improving aerobic capacity, HIIT also shows an increase in muscle mitochondrial markers and a decrease in hyperglycemia levels, which have a positive impact on overweight and obese individual 11. HIIT also has an impact on reducing body fat percentage, thereby lowering the risk of health issues in the overweight population12.

Efforts to improve and maintain health amidst a modern lifestyle that prioritizes time efficiency are greatly needed, especially for vulnerable groups, such as the overweight population. Duration has become a frequent reason for low participation in regular exercise. HIIT has shown advantages over MICT in terms of its time efficiency11. It is important to understand and examine how both HIIT and MICT can induce positive changes in the body. Researchers have found the need for further studies on overweight adolescents to present feasible and effective exercise program options by conducting research entitled "Differences in Effect of High-Intensity Interval Training and Moderate-Intensity Continuous Training on CRF and Waist-To-Hip Ratio in Overweight Adolescents in Denpasar."

2. METHOD (10 PT)

Study design

This study used an experimental research design with a randomized control group pretest-posttest design. Group 1 received HIIT treatment and group 2 received MICT treatment on the influence of CRF and WHR in overweight adolescents. This study was approved by the Faculty of Medicine, Udayana University/Sanglah General Hospital, Denpasar, with ethical clearance number 1490/UN14.2.2. VII.14/LT/2025. Subsequently, the research began with an explanation of the procedures and benefits of the study to the respondents.

Subjects recruitment

The participants of this study were overweight adolescents in Denpasar. The inclusion criteria for this study were females aged 14 – 17 years, normal vital signs, overweight BMI of 23 - 24.9 kg/m^2, and low physical activity (<600 MET-min/week) using the International Physical Activity Questionnaire Short Form (IPAQ-SF), and agreement to become subjects by signing an informed consent form. Subjects with a history of cardiorespiratory disease and those recovering from lower or upper limb injuries were excluded from this study.

Sampling technique

Participants who meet the inclusion and exclusion criteria were then sampled through purposive sampling. The number of samples that passed the screening process was then selected using random allocation. Respondents were divided into two groups. Group 1 received HIIT treatment, whereas group 2 received MICT treatment.

Material and procedure

Material

Data collection used to support the research required the International Physical Activity Questionnaire-Short Form (IPAQ-SF) and the 24-hour Food Recall questionnaire (FR 24 h) to determine the inclusion criteria. Then, the ADVAN S1 smartwatch and Da Fit application were used during training sessions to monitor HRmax. The 20-meter shuttle run test (20m-SRT) accompanied by an mp3 audio was used to measure CRF, and a measuring tape or medline was used to measure WHR.

Procedures
The participants received an explanation beforehand regarding the interventions of each group. Group 1 performed a training program with a 5-minute warm-up, followed by Tabata-HIIT according to weekly progressivity, and concluded with a 5-minute cool-down. Group 2 performed a training program with a 5-minute warm-up, followed by 30 minutes of jogging, and concluded with a 5-minute cool-down. The training was conducted repeatedly, twice a week, over a period of 8 weeks, with a total of 16 sessions.

a. Assessment
CRFis measured as the ratio of maximal oxygen consumption (VO2max). The measuring tool used was the 20-m SRT or the beep/bleep test. The calculation of VO2max uses the results of the number of shuttles and the maximum level that the subject can achieve. Participant were considered to have failed or reached their maximum limit when they were unable to maintain the interval and did not reach the line on time twice in a row. An interpretation of <31 ml/kg/min indicates a low level of fitness. The ratio is obtained through anthropometric measurements by comparing waist circumference (WR) and hip circumference (HR) using a measuring tape or medline in centimeters. The interpretation of WHR values ≥0.85 for women indicates an increased risk of cardiovascular and metabolic diseases. Sample measurements were conducted before and after the intervention program.

b. Data analysis
This research uses Statistical software SPSS version 25. The characteristics of the research subjects were age, body mass index (BMI), level of physical activity, and daily consumption. Normality tests were conducted using the Shapiro-Wilk test, and data homogeneity using Levene's test. Pre- and post-treatment effects were analyzed using the Paired Simple T-test or Wilcoxon test. Comparative analysis between groups was performed using the independent samples t-test or Mann-Whitney U-test. Significant differences were indicated by a p-value <0.05.

3. RESULTS AND DISCUSSION (10 PT)

3.1. Characteristics of research subjects

The characteristics of the research subjects, including age, BMI, level of physical activity, and daily consumption before the treatment was administered, are presented in Table 1.

Table 1 Characteristics of research subjects

Characteristics	Group I (n=10) Mean±SD	Group II (n=10) Mean±SD	*p*
Age (years)	16,7 ± 0,483	16,5 ± 0,527	0,374
Body Mass Index (kg/m^2)	24,94 ± 0,2066	24,329 ± 0,9755	0,692
IPAQ-SF (METs)	489,5 ± 94,824	490,8 ± 100,544	0,791
Food Recall 24-Hour (kcal)	2278,48 ± 479,0363	2429,12 ± 762,1204	0,880

The data in Table 1 show that the characteristics of the research subjects were equal (p>0.05), including age as adolescent, overweight BMI, low IPAQ-SF, and FR 24-hour with excessive daily consumption.

The characteristics of the 20 participants are shown in detail in Table 1. The age criteria indicated that both groups consisted of adolescents, as indicated by the statistical analysis (p>0.05). The average age of Group one is 16.7 and Group two was 16.5. During adolescence, there is an increase in psychosocial pressure related to physical and emotional aspects. Adolescent girls are more vulnerable to behavioral changes, such as decreased sleep quality, increased appetite, especially for sweet foods, and decreased activity in an effort to cope with stress from the environment or social interactions13.
Based on the analysis results, all research participants had an overweight BMI and showed no significant differences in BMI characteristics between the groups (p = 0.692). being overweight in adolescence is closely associated with the occurrence of obesity in adulthood. This has an impact on health, such as an increased risk of degenerative diseases, hypertension, and metabolic syndrome in adulthood14.
Physical activity is closely associ ated with being overweight. This is consistent with a literature review conducted by Banjarnahor, who mentioned that adolescents who only engage in low-level physical activity are six times more at risk of becoming obese15. Low daily physical activity results in decreased skeletal muscle activity and metabolic needs, and this behavior in the long term affects endothelial dysfunction, vascular pressure, left ventricular stiffness, and blood pressure changes, which ultimately reflect a decrease in CRF16.
Diet is a predictor of being overweight. Excessive consumption of high-carbohydrate and low-nutrient foods often occurs in adolescents. Snacks often disrupt meal intake owing to their high sugar levels 15. Based on the analysis of food recall, 24-hour questionnaire data that depicts the diet of individuals in subjects show that both groups have excessive energy intake with an average of 2278.48 kcal in Group one and 2429.12 kcal in Group two. Diet and macronutrient proportions affect body composition and metabolism17.
Data analysis showed that the characteristics of the research subjects in both groups were not significantly different.

Based on this, it can be concluded that both Group one and Group two have similar initial characteristics. The results obtained after conducting the eight-week training program in both groups were influenced by the treatment applied to each group.

3.2. Results of the analysis of the improvement in CRF and the decrease in WHR pre and post exercise

Table 2 Results of the analysis of the improvement in CRF and the decrease in WHR pre and post exercise

	Group I				**GroupII**			
	Mean (mL/kg/minutes) ±SD	***Z***		***p***	**Mean (mL/kg/minutes) ±SD**	***Z***		***p***
VO_2max Pretest	23.11 ± 1.127	-2.807		0,005	22.810±1,097	-2.810		0,005
VO_2max Postest	31.990±1.101				30.450±0,587			
	Mean± SD	**CI 95%**		***p***	**Mean± SD**	**CI 95%**		***p***
		Low	***Up***			***Low***	***Up***	
WHR Pretest	0.887 ± 0.024	0.044	0.093	0.000	0.873± 0.025	0,013	0,052	0.004
WHR Postest	0.821± 0.015				0.840± 0.024			

Analysis of the improvement in CRF and the decrease in WHR before and after exercise are shown in Table 2, and the results of the mean difference test using the Wilcoxon signed-rank test on respiratory fitness showed that there was significant improvement in CRF (<0.05). Meanwhile, the results of the paired sample t-test showed a significant decrease in WHR (<0.05).

3.2.1 High Intensity Interval Training (HIIT) Can Improve CRF in Overweight Adolescents in Denpasar

The high-intensity interval training (HIIT) program improved CRF in overweight adolescent girls. The average pre-test was 23.11 mL/kg/min, which increased in the post-test to 32.00 mL/kg/min (p=0.005). HIIT is programmed exercise training characterized by physical stress until the body produces an adaptive response18. Research has shown an increase in VO2max in the HIIT Group by 8.89 mL/kg/min (p = 0.001). These results are consistent with those of Sadeghi, who found that HIIT for a duration of 8 weeks in overweight subjects was able to improve cardiorespiratory fitness19. The effect depends on the intensity applied, and high intensity is capable of initiating cardiovascular adaptations.

Increased tolerance to metabolic stress is reflected through changes in the energy metabolism and oxidative capacity of muscle cells. The intensity and intervals of HIIT create a combination of aerobic and anaerobic exercises that affect ATP production. The management of carbohydrate and glycogen levels in the body increases as an aerobic response, accompanied by enhanced ammonia disposal processes and increased tolerance to lactic acid as an anaerobic response. Regulation of cellular metabolism results in an increase in mitochondrial gene transcription through activation of PGC-1α, resulting in enhanced mitochondrial protein production. This mechanism increases the production of mitochondria and is responded to by the body through the increased capacity of muscles to maximally use oxygen 20. Another study by Cao supports this theory through a similar study on obese subjects, where HIIT showed an increase in VO2max by 4.5±1.6, from 39.3 mL/kg/min to 43.8 mL/kg/min with a p-value of 0.001 (p<0.05)21. HIIT can increase stroke volume due to enhanced cardiac contractility and improved skeletal muscle diffusion capacity, thereby increasing aerobic capacity. An increase in VO2max reflects an improvement in the efficiency of the cardiopulmonary system and oxygen transport.

3.2.2 High Intensity Interval Training (HIIT) Can Reduce WHR in Overweight Adolescents in Denpasar

The high-intensity interval training (HIIT) exercise program showed a decrease in WHR, indicating a reduction in cardiometabolic risk among overweight adolescent female students. Group one had a pre-test mean of 0.887, which decreased to a post-test mean of 0.821 (p=0.000). The results of this study are in line with those of a previous research conducted by Sun on adolescent subjects22. HIIT with an eight-week program duration showed a significant decrease in WHR, with a p-value of 0.003 (p<0.05). The decrease in WHR is in line with the reduction in visceral fat, which correlates with waist circumference. Metabolic adaptation occurs through the reduction of insulin resistance, and a decrease in visceral fat lowers inflammatory markers, thereby increasing insulin sensitivity.

HIIT with the Tabata technique can increase the total amount and duration of Excess Post-Exercise Oxygen Consumption (EPOC) during the recovery interval period. An increase in energy expenditure can lead to improved fat burning efficiency during the recovery period and enhance the basal metabolic rate, contributing to changes in body composition23. A study conducted by Mohammadi also showed positive results from the influence of HIIT on WHR. The HIIT group demonstrated significant changes with a p-value of 0.001 (p<0.05). The increase in metabolism supports the mechanism of increased mitochondrial numbers and catecholamine activity, with β-adrenergic receptors

subsequently triggering lipolysis to provide free fatty acids as an energy source. The increase in energy expenditure and decrease in appetite after exercise lead to efficient fat burning, including visceral fat, thereby reducing waist circumference, followed by WHR24.

3.2.3 Moderate Intensity Continuous Training (MICT) Can Improve CRF in Overweight Adolescents in Denpasar

The moderate-intensity continuous training (MICT) exercise program showed an increase in CRF among overweight adolescent girls. Group two showed a pre-test average of 22.81 mL/kg/min, which increased to 32.45 mL/kg/min in the post-test (P=0.005). This study is in line with the research by Su, which was conducted over eight weeks on obese adolescents and showed a significant increase in CRF of 3.49±1.53 mL/kg/min ($p<0.001$)25. This study validated that MICT results in improvements in endothelial function and vascular elasticity, thereby supporting the optimization of oxygen transport. During exercise, there is an increase in metabolic needs, and cellular adaptation occurs through enhanced mitochondrial biogenesis to meet energy demands. An increase in the number and function of mitochondria supports the body by enhancing oxygen transport to produce ATP26.

In line with the research by Gejl, it has been stated that a moderate-intensity exercise program can lead to an increase in VO2max27. This can be achieved through adaptive mechanisms, including increased blood volume, heart dimensions, and heart contractility. In adolescents, the response to increased endurance is shown by enlargement of the atrial and ventricular dimensions, both of which are closely related to V̇O2max. Another study by Davis supports the statement that aerobic exercise can improve CRF in overweight children28. The 40-minute aerobic exercise program showed a VO2peak result of +2.7 mL/kg/min. The frequency and intensity of consistent exercise are the main factors supporting changes in metabolic markers that affect circulatory efficiency. Improvements in metabolic conditions support the enhancement of cardiorespiratory function.

3.2.4 Moderate-Intensity Continuous Training (MICT) Can Reduce WHR in Overweight Adolescents in Denpasar

The moderate-intensity continuous training (MICT) exercise program showed a decrease in WHR, indicating a reduction in cardiometabolic risk among overweight adolescent girls. Group two had a pre-test mean of 0.873, which decreased to a post-test mean of 0.840 ($p=0.004$). This study is in line with previous research by Song, who stated that there was a decrease in WHR in the research subjects of obese women29. The underlying reason for this result is an increase in fat metabolism, which occurs in response to increased respiration and energy supply. The long duration of MICT, which in this study was conducted for 35 min, is one of the factors contributing to the increase in fat burning in relation to the body's response in meeting the energy requirements during exercise.

The increase in lipolysis causes a decrease in plasma insulin and catecholamine levels, which are closely related to exercise intensity. This mechanism results in a better response to the absorption of fatty acids in visceral fat. Visceral fat tissue is metabolically more active and has higher expression of β-adrenergic receptors than subcutaneous fat. Thus, the lipolysis response depends on the level of activity, and one way to achieve this is by using MICT30.

Previous research by Martins concluded that there were changes in body composition after MICT. The more significant reduction in abdominal fat at waist circumference reflects the efficiency of using visceral fat as an energy source. This makes MICT able to reduce WHR as a reflection of cardiometabolic risk31.

3.3. The results of the analysis of the improvement in CRF and the decrease in WHR between groups

Table 3 Comparison results of the the improvement in CRF and the decrease in WHR between groups

	Group I		**Group II**		***Z***	***p***
	Mean (mL/kg/minutes) ±SD	**Median**	**Mean (mL/kg/minutes) ±SD**	**Median**		
VO_2max	31.990±1.101	31.60	30.450±0.5874	30.45	-3.209	0.001
				CI 95%		***p***
				Low	**Up**	
WHR	0.821± 0.015		0.840± 0.024	-0.0398	0.0008	0.059

As shown in Table 3, the results of the comparison test using the Mann-Whitney U-test showed significant differences between groups ($p<0.05$). It can be concluded that HIIT is better than MICT at improving CRF. The results of the comparison test using the independent sample t-test showed no significant differences between the groups ($p>0.05$).Thus, it can be concluded that HIIT and MICT are equally effective in reducing WHR.

Table 4 Results of daily consumption analysis before and after the training program in group 1

	Group I (n=10)	**Group II (n=10)**

	Mean±SD		Mean±SD	
	Before	**After**	**Before**	**After**
Food Recall 24-Hour (kcal)	2278.48 ± 479.0363	1947.34 ± 201.4841	2429.12 ± 762.1204	1934.93±217.8387

Based on Table 4, the data show that the research subjects exhibit changes in daily consumption that reflect a decrease in the amount consumed and changes in diet.

3.3.1 High Intensity Interval Training (HIIT) is More Effective Compared to Moderate-Intensity Continuous Training (MICT) in Improving CRF in Overweight Adolescents in Denpasar

The results of the statistical analysis showed a significant difference between Group One and Group Two in the improvement of CRF in overweight adolescents (p=0.001). Therefore, HIIT is better than MICT for improving cardiorespiratory fitness. Disruption of fat metabolism in overweight adolescents results in higher homocysteine levels than in the population with normal BMI. As a result, vascular endothelial function decreases, and cardiovascular risk increases32. This study used the Tabata-type HIIT, which applies high metabolic stress through body weight or a combination of functional movements, thereby supporting intramuscular coordination and muscle endurance. The aerobic and anaerobic energy release systems that occur in Tabata-HIIT encourage the body to resynthesize ATP. Physiologically, an increase in VO_2max reflects cardiovascular adaptations, including muscle perfusion efficiency and improved oxygen transport system capacity. The improvement in physical performance that occurs efficiently and applicably enhances overall metabolic and CRF33.

In the MICT Group, jogging techniques, which are a conventional form of continuous moderate-intensity exercise, were used. The technique is a training program that has been commonly performed by research subjects, and the program lacks any form of progressiveness. Differences in the progressiveness of each intervention can be one of the factors causing variations in their effects on physiological adaptation. Tabata-HIIT can meet the training principle of progressive overload, which does not occur in MICT. This is one of the factors that causes differences in physiological adaptation34.

Findings from several previous studies have shown the effectiveness of HIIT compared to MICT. Research conducted by Cvetković showed a result of p=0.025 in the population of overweight to obese children, whereas Dias reported a result of p=0.004 in the population of obese children35,36. Both studies reached conclusions that align with the findings of this research, where HIIT was more effective than MICT in improving cardiorespiratory fitness. The body's mechanisms of supplying energy during exercise support adaptations in oxygen transport and extraction, cardiac output, peripheral perfusion, and muscle oxidation capacity, as well as an increase in mitochondrial oxidation capacity, making HIIT more effective than MICT37.

Psychological changes can support adherence levels as a success factor in an exercise program. Li explained that HIIT has advantages in movement variation and exercise duration38. The presence of intervals makes the workout more dynamic and less monotonous than continuous exercise. HIIT can reduce boredom and elicit positive psychological responses because of the perception of achieving change with short-duration workouts. Positive changes in self-confidence also occur as a result of achieving desired physical capacity.

Differences in intensity play a crucial role in the post-training program results. This is due to the difference in training volume in achieving physiological adaptations both centrally (heart function) and peripherally (muscle mitochondrial function), where MICT with moderate intensity requires a longer program duration than HIIT39. Thus, HIIT is a more effective training program for overweight adolescents to achieve improvements in cardiorespiratory fitness.

3.3.2 High Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) Are Equally Effective in Reducing WHR in Overweight Adolescents in Denpasar

The results of the statistical analysis showed no significant difference between Group one and Group two in the reduction of WHR in overweight adolescents (P=0.059). Therefore, HIIT is as effective as MICT in reducing the waist-to-hip ratio. Exercise or workout programs are important factors in the process of body composition change towards weight loss. Regardless of dietary changes, the duration and intensity of exercise significantly influences the maintenance of muscle mass, which often decreases during weight loss 40.

Total energy expenditure (TEE) comprises several components, including activity energy expenditure (AEE). AEE is the most variable component of the TEE. Factors that influence AEE include the intensity, duration, and frequency of activity41. AEE is enhanced through the provision of exercises such as HIIT and MICT, which trigger an EPOC period as a reaction to the increase in energy expenditure. This mechanism serves as the basis for the influence of intensity on the rate of fat burning42.

Aerobic and anaerobic exercises support changes in body composition by reducing fat mass and increasing muscle mass. Short-term HIIT has been proven effective in reducing abdominal fat through increased EPOC as an energy-fulfillment response. However, various studies have shown that these mechanisms do not affect the reduction in adipocyte size or weight loss; therefore, changes in body composition are often considered to be insignificant43. MICT does not induce high metabolic stress; therefore, the physiological response post-exercise is not as pronounced as that

of HIIT. HIIT and MICT result in changes in mitochondrial function and biogenesis in adipose tissues. Insignificant differences in adaptation can occur because of achieving equivalent stimulus levels, but with different exercise durations. This also demonstrates the advantage of HIIT as a training program with a shorter duration, but can achieve effectiveness equivalent to that of conventional MICT training programs44.

Gonçalves states that both intervention groups showed significant changes in body composition, where HIIT and MICT were equivalent in their effectiveness in reducing abdominal fat45. Another study by Armannia stated that WHR did not differ significantly ($p>0.05$) owing to the influence of exercise duration46. Another study by Rohmansyah showed similar value increases in both groups, both in waist circumference and hip circumference, thus supporting the assumption that HIIT and MICT have equivalent levels of effectiveness47. Both are capable of reducing visceral fat levels and improving vascular function through their respective mechanisms to meet the energy supply48. A further review of the daily consumption of both groups is shown in Table 4, which shows a specific decrease in daily consumption. This could be an effect of education regarding both the exercise program and BMI status, which may encourage subjects to improve their diet and support changes in body composition in this study. Based on this explanation, HIIT and MICT are equally effective exercise programs for overweight adolescents to achieve a reduction in WHR as an indicator of cardiometabolic risk.

4. CONCLUSION (10 PT)

High-intensity interval training (HIIT) is better than moderate-intensity continuous training (MICT) for improving CRF in overweight adolescents in Denpasar. However, high-intensity interval training (HIIT) is as effective as moderate-intensity continuous training (MICT) in reducing waist-to-hip ratio in overweight adolescents. Further research is recommended with dietary control during the training program through periodic recalls, application of the progressive overload principle in both interventions, and an extension of the research duration.

ACKNOWLEDGEMENTS (10 PT)

The researchers express their gratitude to all parties involved in the study, especially SMA Muhammadiyah 1 Denpasar, for hosting the implementation of this research.

REFERENCES (10 PT)

[1] A. A. Wenni, H. Nasruddin, L. T. Limoa, A. Makmun, and H. Hasan, "Hubungan Aktivitas Fisik Dan Sedentary Lifestyle Dengan Status Gizi Mahasiswa Program Profesi Dokter Angkatan 2017 FK UMI," *Fakumi Medical Journal*, vol. 3, no. 6, pp. 444–451, 2023.

[2] D. Thivel, A. Tremblay, P. M. Genin, S. Panahi, D. Rivière, and M. Duclos, "Physical Activity, Inactivity, and Sedentary Behaviors: Definitions and Implications in Occupational Health," Oct. 05, 2018, *Frontiers Media S.A.* doi: 10.3389/fpubh.2018.00288.

[3] E. C. Chin *et al.*, "Low-Frequency HIIT Improves Body Composition And Aerobic Capacity In Overweight Men," *Med Sci Sports Exerc*, vol. 52, no. 1, pp. 56–66, Jan. 2020, doi: 10.1249/MSS.0000000000002097.

[4] R. Guthold, G. A. Stevens, L. M. Riley, and F. C. Bull, "Global Trends In Insufficient Physical Activity Among Adolescents: a Pooled Analysis Of 298 Population-Based Surveys With 1·6 Million Participants," *Lancet Child Adolesc Health*, vol. 4, no. 1, pp. 23–35, Jan. 2020, doi: 10.1016/S2352-4642(19)30323-2.

[5] Riskesdas, *Laporan Nasional Riskesdas 2018*. Jakarta: Badan Penelitian dan Pengembangan Kesehatan, 2018.

[6] S. U. Amrynia and G. N. Prameswari, "Hubungan Pola Makan, Sedentary Lifestyle, dan Durasi Tidur dengan Kejadian Gizi Lebih Pada Remaja (Studi Kasus di SMA Negeri 1 Demak)," *Indonesian Journal of Public Health and Nutrition*, vol. 2, no. 1, pp. 112–121, Mar. 2022, doi: 10.15294/ijphn.v2i1.52044.

[7] N. K. Wiardani and A. A. N. Kusumajaya, "Perilaku Makan, Aktivitas Fisik, dan Penggunaan Internet Pada Remaja Sekolah Yang Mengalami Obesitas Di Provinsi Bali," *GIZI INDONESIA*, vol. 46, no. 2, pp. 207–220, Sep. 2023, doi: 10.36457/gizindo.v46i2.794.

[8] M. J. Joyner and P. B. Dominelli, "Central cardiovascular system limits to aerobic capacity," *Exp Physiol*, vol. 106, no. 12, pp. 2299–2303, 2021, doi: 10.1113/EP088187.

[9] M. D'Alleva *et al.*, "Effects of combined training or moderate intensity continuous training during a 3-week multidisciplinary body weight reduction program on cardiorespiratory fitness, body composition, and substrate oxidation rate in adolescents with obesity," *Sci Rep*, vol. 13, no. 1, Dec. 2023, doi: 10.1038/s41598-023-44953-3.

[10] Z. Guo, M. Li, J. Cai, W. Gong, Y. Liu, and Z. Liu, "Effect of High-Intensity Interval Training vs. Moderate-Intensity Continuous Training on Fat Loss and Cardiorespiratory Fitness in the Young and Middle-

Aged a Systematic Review and Meta-Analysis," *Int J Environ Res Public Health*, vol. 20, no. 6, 2023, doi: 10.3390/ijerph20064741.
[11] B. J. Ryan *et al.*, "Moderate-Intensity Exercise and High-Intensity Interval Training Affect Insulin Sensitivity Similarly in Obese Adults," *Journal of Clinical Endocrinology and Metabolism*, vol. 105, no. 8, pp. E2941–E2959, Aug. 2020, doi: 10.1210/clinem/dgaa345.
[12] R. Martin-Smith, A. Cox, D. S. Buchan, J. S. Baker, F. Grace, and N. Sculthorpe, "High Intensity Interval Training (HIIT) Improves Cardiorespiratory Fitness (CRF) In Healthy, Overweight And Obese Adolescents: A Systematic Review And Meta-Analysis Of Controlled Studies," Apr. 02, 2020, *MDPI*. doi: 10.3390/ijerph17082955.
[13] E. K. Andrie *et al.*, "Psychosocial Factors And Obesity In Adolescence: a Case-Control Study," *Children*, vol. 8, no. 4, Apr. 2021, doi: 10.3390/children8040308.
[14] W. Wijianto, P. Candriasih, Sukmawati, Nurarifah, and F. Hafid, "Hubungan Pengetahuan Dan Prilaku Risiko Obesitas Terhadap Kejadian Obesitas Remaja Pada Masa Pandemi Covid 19," *Svasta Harena: Jurnal Ilmiah Gizi*, vol. 4, no. 1, pp. 26–33, Aug. 2023, doi: 10.33860/shjig.v4i1.1759.
[15] R. O. Banjarnahor, F. F. Banurea, J. O. Panjaitan, R. S. P. Pasaribu, and I. Hafni, "Faktor-Faktor Risiko Penyebab Kelebihan Berat Badan dan Obesitas Pada Anak dan Remaja: Studi Literatur," *Tropical Public Health Journal*, vol. 2, no. 1, pp. 35–45, Mar. 2022, doi: 10.32734/trophico.v2i1.8657.
[16] S. A. Prince *et al.*, "The Effect of Sedentary Behaviour on Cardiorespiratory Fitness: A Systematic Review and Meta-Analysis," Apr. 01, 2024, *Springer Science and Business Media Deutschland GmbH*. doi: 10.1007/s40279-023-01986-y.
[17] L. Zhao *et al.*, "Effects of Exercise Combined with Diet Intervention on Body Composition and Serum Biochemical Markers in Adolescents with Obesity: a Systematic Review and Meta-analysis," Nov. 01, 2022, *De Gruyter Open Ltd*. doi: 10.1515/jpem-2022-0193.
[18] A. Fatikhawati, K. Prahasanti, and C. Efendi, "Perbandingan Pengaruh Latihan Fisik Interval Tinggi Dengan Kontinu Terhadap Heart Rate Istirahat, VO2Max Dan Heart Rate Recovery Pada Atlet Renang Pria POR SURYANAGA Surabaya," *JOSSAE : Journal of Sport Science and Education*, vol. 6, no. 1, p. 35, Apr. 2021, doi: 10.26740/jossae.v6n1.p35-45.
[19] J. Sadeghi, A. Monazzami, and A. Taheri Kalani, "Effects of Eight-Week High-Intensity Interval Training on Aerobic Performance, Lipid Profile, and Hematological Indices in Overweight Adolescents," *Jundishapur Journal of Health Sciences*, vol. 13, no. 2, Jul. 2021, doi: 10.5812/jjhs.110645.
[20] B. Hernawan and R. A. A. A. Putra, "Pengaruh High Intensity Interval Training (HIIT) Terhadap Nilai VO2 Maks pada Orang Dewasa Muda: Literature Review," *Jendela Olahraga*, vol. 8, no. 2, pp. 43–52, Aug. 2023, doi: 10.26877/jo.v8i2.14015.
[21] M. Cao, Y. Tang, and Y. Zou, "Integrating High-Intensity Interval Training into a School Setting Improve Body Composition, Cardiorespiratory Fitness and Physical Activity in Children with Obesity: A Randomized Controlled Trial," *J Clin Med*, vol. 11, no. 18, Sep. 2022, doi: 10.3390/jcm11185436.
[22] F. Sun, C. A. Williams, Q. Sun, F. Hu, and T. Zhang, "Effect Of Eight-Week High-Intensity Interval Training Versus Moderate-Intensity Continuous Training Programme On Body Composition, Cardiometabolic Risk Factors In Sedentary Adolescents'," *Front Physiol*, vol. 15, 2024, doi: 10.3389/fphys.2024.1450341.
[23] Y. Wang *et al.*, "Combined High-Intensity Interval and Resistance Training Improves Cardiorespiratory Fitness More Than High-Intensity Interval Training In Young Women With Overweight/Obesity: A Randomized Controlled Trial'," *Front Endocrinol (Lausanne)*, vol. 15, 2024, doi: 10.3389/fendo.2024.1450944.
[24] S. Mohammadi, A. Monazzami, and S. alavimilani, "Effects Of Eight-Week High-Intensity Interval Training On Some Metabolic, Hormonal And Cardiovascular Indices In Women With PCOS: A Randomized Controlled Trail'," *BMC Sports Sci Med Rehabil*, vol. 15, no. 1, Dec. 2023, doi: 10.1186/s13102-023-00653-z.
[25] Z. Su *et al.*, "Comparison Of High-Intensity Interval Training And Moderate-Intensity Continuous Training On Cardiopulmonary Function, Cardiac Autonomic Function And Vascular Function In Adolescent Boys With Obesity: a Randomized Controlled Trial," *Eur J Sport Sci*, Dec. 2024, doi: 10.1002/ejsc.12207.
[26] K. Pinckard, K. K. Baskin, and K. I. Stanford, "Effects of Exercise to Improve Cardiovascular Health," Jun. 04, 2019, *Frontiers Media S.A.* doi: 10.3389/fcvm.2019.00069.
[27] A. K. Gejl, A. Bugge, M. T. Ernst, E. L. Mortensen, K. D. Gejl, and L. B. Andersen, "Effects of 9 Weeks of High- or Moderate-Intensity Training on Cardiorespiratory Fitness, Inhibitory Control, and Plasma Brain-Derived Neurotrophic Factor in Danish Adolescents—A Randomized Controlled Trial," *Scand J Med Sci Sports*, vol. 34, no. 8, Aug. 2024, doi: 10.1111/sms.14703.
[28] C. L. Davis *et al.*, "Exercise Effects on Arterial Stiffness and Heart Health in Children with Excess Weight: The SMART RCT," *Int J Obes*, vol. 44, no. 5, pp. 1152–1163, May 2020, doi: 10.1038/s41366-019-0482-1.

[29] X. Song *et al.*, "Comparative Effects of High-Intensity Interval Training and Moderate-Intensity Continuous Training on Weight and Metabolic Health in College Students with Obesity," *Sci Rep*, vol. 14, no. 1, Dec. 2024, doi: 10.1038/s41598-024-67331-z.
[30] S. M. Honkala *et al.*, "Exercise Training Improves Adipose Tissue Metabolism And Vasculature Regardless Of Baseline Glucose Tolerance And Sex," *BMJ Open Diabetes Res Care*, vol. 8, no. 1, Aug. 2020, doi: 10.1136/bmjdrc-2019-000830.
[31] C. Martins *et al.*, "High-Intensity Interval Training and Isocaloric Moderate-Intensity Continuous Training Result in Similar Improvements in Body Composition and Fitness in Obese Individuals," *Int J Sport Nutr Exerc Metab*, vol. 26, no. 3, pp. 197–204, Jun. 2016, doi: 10.1123/ijsnem.2015-0078.
[32] C. Wang, Z. Tian, Y. Hu, and Q. Luo, "Physical Activity Interventions For Cardiopulmonary Fitness In Obese Children And Adolescents: a Systematic Review And Meta-Analysis," *BMC Pediatr*, vol. 23, no. 1, Dec. 2023, doi: 10.1186/s12887-023-04381-8.
[33] I. Tabata, "Tabata Training: One of The Most Energetically Effective High-Intensity Intermittent Training methods," Jul. 01, 2019, *Springer Tokyo*. doi: 10.1007/s12576-019-00676-7.
[34] M. Cao, M. Quan, and J. Zhuang, "Effect of High-Intensity Interval Training versus Moderate-Intensity Continuous Training on Cardiorespiratory Fitness in Children and Adolescents: A Meta-Analysis," *Int J Environ Res Public Health*, vol. 16, no. 9, p. 1533, Apr. 2019, doi: 10.3390/ijerph16091533.
[35] N. Cvetković, E. Stojanović, N. Stojiljković, D. Nikolić, A. T. Scanlan, and Z. Milanović, "Exercise Training In Overweight And Obese Children: Recreational Football And High-Intensity Interval Training Provide Similar Benefits To Physical Fitness," *Scand J Med Sci Sports*, vol. 28, pp. 18–32, Aug. 2018, doi: 10.1111/sms.13241.
[36] K. A. Dias *et al.*, "Effect of High-Intensity Interval Training on Fitness, Fat Mass and Cardiometabolic Biomarkers in Children with Obesity: A Randomised Controlled Trial," *Sports Medicine*, vol. 48, no. 3, pp. 733–746, Mar. 2018, doi: 10.1007/s40279-017-0777-0.
[37] M. Cao, Y. Tang, S. Li, and Y. Zou, "Effects Of High-Intensity Interval Training And Moderate-Intensity Continuous Training On Cardiometabolic Risk Factors In Overweight And Obesity Children And Adolescents: A Meta-Analysis Of Randomized Controlled Trials," Nov. 01, 2021, *MDPI*. doi: 10.3390/ijerph182211905.
[38] F. Li *et al.*, "High-Intensity Interval Training Elicits More Enjoyment and Positive Affective Valence Than Moderate-Intensity Training Over a 12-Week Intervention in Overweight Young Women," *J Exerc Sci Fit*, vol. 20, no. 3, pp. 249–255, Jul. 2022, doi: 10.1016/j.jesf.2022.05.001.
[39] J. Liu, L. Zhu, and Y. Su, "Comparative Effectiveness Of High-Intensity Interval Training And Moderate-Intensity Continuous Training For Cardiometabolic Risk Factors And Cardiorespiratory Fitness In Childhood Obesity: a Meta-Analysis Of Randomized Controlled Trials," *Front Physiol*, vol. 11, Apr. 2020, doi: 10.3389/fphys.2020.00214.
[40] D. McCarthy and A. Berg, "Weight Loss Strategies and the Risk of Skeletal Muscle Mass Loss," *Nutrients*, vol. 13, no. 7, Jul. 2021, doi: 10.3390/nu13072473.
[41] D. Ndahimana and E.-K. Kim, "Measurement Methods for Physical Activity and Energy Expenditure: a Review," *Clin Nutr Res*, vol. 6, no. 2, p. 68, 2017, doi: 10.7762/cnr.2017.6.2.68.
[42] L. Jiang, Y. Zhang, Z. Wang, and Y. Wang, "Acute Interval Running Induces Greater Excess Post-exercise Oxygen Consumption and Lipid Oxidation Than Isocaloric Continuous Running in Men with Obesity," *Sci Rep*, vol. 14, no. 1, p. 9178, Apr. 2024, doi: 10.1038/s41598-024-59893-9.
[43] K. J. Kolnes, M. H. Petersen, T. Lien-Iversen, K. Højlund, and J. Jensen, "Effect of Exercise Training on Fat Loss—Energetic Perspectives and the Role of Improved Adipose Tissue Function and Body Fat Distribution," Sep. 24, 2021, *Frontiers Media S.A.* doi: 10.3389/fphys.2021.737709.
[44] C. Ahn *et al.*, "Exercise Training Remodels Subcutaneous Adipose Tissue in Adults with Obesity Even without Weight Loss," *Journal of Physiology*, vol. 600, no. 9, pp. 2127–2146, May 2022, doi: 10.1113/JP282371.
[45] C. Gonçalves, A. Raimundo, A. Abreu, J. Pais, and J. Bravo, "Effects of High-Intensity Interval Training vs Moderate-Intensity Continuous Training on Body Composition and Blood Biomarkers in Coronary Artery Disease Patients: A Randomized Controlled Trial," *Rev Cardiovasc Med*, vol. 25, no. 3, 2024, doi: 10.31083/J.RCM2503102.
[46] F. Armannia, F. Ghazalian, M. Shadnoush, H. Keyvani, and M. Gholami, "Effects of High-Intensity Interval Vs. Moderate-Intensity Continuous Training on Body Composition and Gene Expression of ACE2, NLRP3, and FNDC5 in Obese Adults: A Randomized Controlled Trial," *Med J Islam Repub Iran*, vol. 36, no. 1, 2022, doi: 10.47176/mjiri.36.161.
[47] N. A. Rohmansyah, R. Ka Praja, Y. Phanpheng, and A. Hiruntrakul, "High-Intensity Interval Training Versus Moderate-Intensity Continuous Training for Improving Physical Health in Elderly Women," *Inquiry (United States)*, vol. 60, Jan. 2023, doi: 10.1177/00469580231172870.

[48] W. Shi *et al.*, “The Effects of High-Intensity Interval Training and Moderate-Intensity Continuous Training on Visceral Fat and Carotid Hemodynamics Parameters in Obese Adults,” *J Exerc Sci Fit*, vol. 20, no. 4, pp. 355–365, Oct. 2022, doi: 10.1016/j.jesf.2022.09.001.